

NORSK POLARINSTITUTT
SKRIFTER NR. 122

MICHAEL FRANK WILLIAM HOLLAND

THE GEOLOGY OF CERTAIN PARTS
OF EASTERN SPITSBERGEN



NORSK POLARINSTITUTT
OSLO 1961

NORSK POLARINSTITUTT

Observatoriegt. 1, Oslo, Norway

Short account of the publications of Norsk Polarinstitut.

The two series published by Norsk Polarinstitut, SKRIFTER and MEDDELELSER, were taken over from the former institution, Norges Svalbard- og Ishavs-undersøkelser (NSIU), which was incorporated in Norsk Polarinstitut, when this was founded in 1948. A third series, Norsk Polarinstitut - ÅRBOK, will be published with one volum per year. The first volume will soon appear.

SKRIFTER includes scientific papers, published in English, French or German. MEDDELELSER comprises shorter papers, often being reprints from other journals. They are generally in a more popular scale and are mostly published in Norwegian.

SKRIFTER has in the past been published under various titles:

Nos. 1—11. Resultater av De norske statsunderstøttede Spitsbergen-ekspedisjoner.

No. 12. Skrifter om Svalbard og Nordishavet.

Nos. 13—81. Skrifter om Svalbard og Ishavet.

• 82—89. Norges Svalbard- og Ishavs-undersøkelser. Skrifter.

• 90— . Norsk Polarinstitut. Skrifter.

Further Norsk Polarinstitut also publishes a special series: NORWEGIAN—BRITISH—SWEDISH ANTARCTIC EXPEDITION, 1949—52. SCIENTIFIC RESULTS. This series will consist of 6 vols. By now 20 papers are published, and the series will probably be completed within 1963.

Topographical and hydrographical surveying also plays an important part of the work done by Norsk Polarinstitut. A list of the published maps and charts is found on the back page of SKRIFTER.

A complete list of publications (including maps and charts) is enclosed in SKRIFTER No. 123.

SKRIFTER

Skrifter nr. 1—89, see numbers of Skrifter previous to Nr. 100.

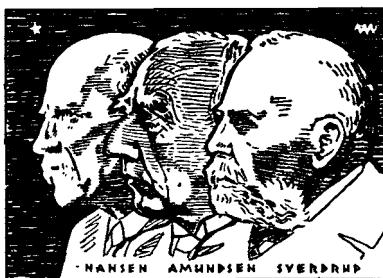
Nr.

90. HENIE, HANS: *Astronomical Observations on Hopen*. 1948. Kr. 3,00.
91. RODAHL, KÅRE: *Vitamin Sources in Arctic Regions*. 1949. Kr. 6,00.
92. RODAHL, KÅRE: *The Toxic Effect of Polar Bear Liver*. 1949. Kr. 12,50.
93. HAGEN, ASBJØRN: *Notes on Arctic fungi. I. Fungi from Jan Mayen. II. Fungi collected by Dr. P. F. Scholander on the Swedish-Norwegian Arctic Expedition 1931*. 1950. Kr. 2,00.
94. FEYLING-HANSEN, ROLF W. and FINN A. JØRSTAD: *Quaternary Fossils*. 1950. Kr. 8,25.
95. RODAHL, KÅRE: *Hypervitaminosis A*. 1950. Kr. 22,50.
96. BUTLER, J. R.: *Geochemical Affinities of some Coals from Svalbard*. 1953. Kr. 3,00.

NORSK POLARINSTITUTT
SKRIFTER NR. 122

MICHAEL FRANK WILLIAM HOLLAND

THE GEOLOGY OF CERTAIN PARTS OF EASTERN SPITSBERGEN



NORSK POLARINSTITUTT
OSLO 1961

Printed December 1961

PUBLISHED BY NORSK POLARINSTITUTT
DISTRIBUTED BY OSLO UNIVERSITY PRESS
OSLO 1961

Contents.

Preface	4
Abstract	5
Introduction	8
Acknowledgements	10
A. Hecla Hoek Rocks in Northern Sabine Land, Vestspitsbergen	10
B. I Permo-Carboniferous Rocks in Northern Sabine Land, Vestspitsbergen	11
B. II Permo-Carboniferous Rocks in Vibe Land, Nordaustlandet	16
B. III The Succession and Structure of the Permo-Carboniferous Rocks of Vibe- høgdene, Nordaustlandet	24
B. IV Permo-Carboniferous Beds and Igneous Rocks in Southern Hinlopenstretet....	27
C. I Mesozoic Rocks in Northern Sabine Land, Vestspitsbergen	30
C. II Mesozoic Rocks in Nordaustlandet	33
C. III Mesozoic Rocks of Wilhelmøya	34
Tables	34
Physiographical History of Wilhelmøya	39
References	42
Postscript	44

The geology of certain parts of eastern Spitsbergen.

By

Michael Frank William Holland.

Preface.

This paper and the accompanying maps and sections were almost completed when the author, Michael Holland, went to Greenland with an International Geophysical Year party in the summer of 1957, where he lost his life (see *Geogr. Journ.* 124, 1958, pp. 77-79).

Since that time some further fossils which he had collected have been identified by Dr. L. R. Cox; these and other changes and additions have been made to the text, which, as far as possible, has been left as Holland wrote it. No attempt has been made to bring it up-to-date to the time of publishing. Naturally, there have been difficulties, but the writer of this note, who was a friend of Holland's and former supervisor of his research work in Oxford, believes that the documentation is correct. Many place names are not official; they are those of Holland's field work, and are used for purposes of identification only. The maps have been adapted from the originals, which were in colour.

The writer wishes to record gratitude to Dr. A. K. Orvin for encouragement that Michael Holland deeply appreciated, and for subsequent interest in the publication of the results; also to the Director of the Norsk Polar-institutt, Dr. Tore Gjelsvik, for his recent invitation that the results should be submitted for publication.

K. S. Sandford

Abstract.

The paper is based on field work carried out on the Oxford University Expeditions to Nordaustlandet in 1951 and Vestspitsbergen in 1953.

In the extreme north of northern Sabine Land Hecla Hoek rocks were found, belonging to Odell's groups (4) and (5) of his Upper Series of the Hecla Hoek (pre-Devonian) rocks and they may be correlated with Kulling's Lower Murchison Bay Formation.

Several sections in Permo-Carboniferous rocks were measured on a journey from Von Postbreen to the snout of Negribreen. At the western end of the mountains on the south side of Von Postbreen Lower Permian Brachiopod Cherts are underlain by Upper Carboniferous Upper Gypsiferous Series of the Cyathophyllum Limestones and these in turn are underlain by Upper Carboniferous 'Wordiekammen Limestones' of the Cyathophyllum Limestones. Inland, that is eastwards along Von Postbreen to Pryzbyllockfjellet, the lower beds become successively overwhelmed by ice and a greater thickness of Brachiopod Cherts is exposed.

The mountains on the south-east side of Potpeschniggbreen and those about the névé field at the head of the glacier (the névé field in the confluence of a series of glaciers trending to the north-west, east, south-east and south-west) all consist of the Brachiopod Cherts. The reconnaissance sledge journey was continued along Edmondbreen to the southeast of Friederichsenfjella; this glacier has the same north-east to south-west trend of Potpeschniggbreen. On the north-western side of the upper regions of this glacier Upper Carboniferous Brachiopod Cherts crop out but further to the north-east at Vivienberget the beds are underlain by sandstones and conglomerates which lie unconformably upon the steeply dipping Hecla Hoek.

On the south-eastern side of this glacier at the north-western end of Perthesfjella, Mesozoic sediments and intrusives crop out but in the range of mountains bordering the southern and south-western flanks of Negribreen only Permo-Carboniferous strata with dolerite intrusions appear, and they constitute the country as far east as the junction of Johansenbreen with Negribreen. Thence as far as Perthesfjella and Wichmannfjellet and possibly to Aagaardfjellet, Mesozoic sediments and intrusives

crop out, as they do in Hahnfjella to the south of the confluence of Petermannbreen with Negribreen.

Mesozoic strata, Permo-Carboniferous and Hecla Hoek beds have been described and mapped by previous workers on the northern and north-eastern side of Negribreen. On Orvin's Map of 1940 no Permo-Carboniferous rocks were indicated on the southern and south-western side of Negribreen and the writer shows them to outcrop widely there in Sandfordfjella, to underlie the Mesozoic strata to the west and to crop out again to the west of Hayesbreen. A considerable adjustment of the geological boundaries in this area has therefore been made. An important fault along the line of the glacier to the south-east of Friederichsenfjella is strongly indicated, and faults and sharp folds are demonstrated in the mountains to the south and south-east of Negribreen.

In 1951 the writer measured the first complete Upper Carboniferous to Lower Permian succession to be found in Nordaustlandet; three sections were examined and an extensive fauna was discovered. Considerable confusion exists in the nomenclature and the dating of the Upper Carboniferous beds of Vestspitsbergen and southern Nordaustlandet but the series found by the author are correlated with the Lower Permian Productus Beds, the Permo-Carboniferous Spirifer Limestones and the Upper Carboniferous Upper Gypsiferous Series of the Cyathophyllum Limestones.

Sandford's conclusions (1926) about the structure beneath Vegafonna and Sørfonna are correct except that the Productus Beds have not been so eroded as to be unrepresented in southern Nordaustlandet. The writer also demonstrates that the Spirifer Limestones do not form the base of the section in the southern area but that they are underlain by the Upper Carboniferous Upper Gypsiferous Series. It is also shown that the red and pink sandstones found by Kulling (1934) on the southern shore of Wahlenbergfjorden and referred by him to Culm are in fact Upper Carboniferous Upper Gypsiferous beds and correlate with the Calciferous Sandstone Series discovered by the author on the south coast of Nordaustlandet.

The structure of Vibehøgdene in southern Nordaustlandet is a gentle anticline pitching to the south-east; much of the surface slopes to the south-west in harmony with the dip. The junction between the Permo-Carboniferous and Mesozoic strata is thought to lie in the depression partly occupied by an icelobe between Vibehøgdene and Svartknausane. To the west of the depression only Triassic and presumed Jurassic sediments and Mesozoic intrusives have been mapped though the writer believes that Permo-Carboniferous rocks may crop out in Torellnesfjellet.

On Wahlbergøya and Nystromøya in Hinlopenstretet dolerites were found upon an eroded surface of folded Permo-Carboniferous rocks and the foldings may represent the first manifestations of the movements which Sandford and others claim to have originated the intrusion of the dolerites, and to have been the inception of the formation of the fjords.

Structures were observed in Permo-Carboniferous and Mesozoic rocks on the west coast of Nordaustlandet in the southern part of Hinlopenstretet, and this has been confirmed from the field work at Svartberget in 1955 by Hollin. The beds here correlate with the Lower Permian *Productus* Beds of Wahlenbergfjorden and Vibehøgdene, and there is increasing support for the contention that Hinlopenstretet was a region of strong and repeated earth movement.

In north Sabine Land, Vestspitsbergen, three sections were measured in Triassic rocks intruded with dolerites which are presumed to be Lower Cretaceous in age. The fauna indicates that sediments in the section from the north-west end of Perthesfjella are Ladinian and those from the sections measured in Hahnfjella and Wichmannfjellet are Lower Triassic in age.

In 1923 De Geer published the geological results of a visit to the island of Wilhelmøya (Tumlingodden) in 1901. In 1951 the writer spent a few hours on the island and managed to measure a section which adds to the detail shown in De Geer's work. The detail is insufficient to prove that a complete Upper Triassic to Upper Jurassic sequence may be found on the island, but this is indicated. The Mesozoic beds in south-west Nordaustlandet have been stratigraphically compared with those from Wilhelmøya and Jurassic as well as Triassic rocks are postulated on the larger island. There is no evidence of strong disturbance in the section measured on Wilhelmøya but many indications that the deposition took place close to a land mass with possible frequent changes of sea level and depth. Late Cretaceous or Tertiary faulting succeeded early Cretaceous intrusion of dolerites and then the main elevation of the island took place, possibly contemporaneously with the Tertiary movements strongly felt in Vestspitsbergen. The latest events have been the Quaternary glaciation and Recent erosion and the deposition of quantities of unconsolidated debris.

Introduction.

The geological work described in this paper covers part of the field investigations of the Oxford University Expeditions to Nordaustlandet in 1951 and to Vestspitsbergen in 1953. (Fig. 1.) A list of the place-names used in the description is included and each one is referred to the map upon which it may be found. The number (1) after a place-name signifies that the name may be found upon "Karte der Wilhelm Filchnerschen Vorekspe-dition nach Zentral Spitsbergen im August, 1910" 1 : 50.000, the number (2) on the maps in Sandford's 1926 paper, the number (3) on Norges Svalbard-og Ishavs-Undersøkelser, 507, Nordstvalbard, 1 : 600.000, the number (4) indicates that the place-names are only the place-names used by the author and they are not official (see Orvin, A. K.: The Place-names of Svalbard, Skrifter om Svalbard og Ishavet, Nr. 80, pp. 1-539, Oslo, 1942, and Roberts, P.: The Polar Record, 5, 1948, pp. 172-184. 1948) and they are included upon the sketches accompanying this paper. Other sources of place-names are shown individually. Certain of the place-names appear on more than one map. Major place-names:

Vestspitsbergen (3), Nordaustlandet (North-East Land) (3), Wilhelm-øya (3), Northern Sabine Land (1), Sabine Land (1), Vibe Land, Olav V Land (Garwood Land, (Odell, 1927)), Hinlopenstretet (3). Fjords: Tempel-fjorden (3), Lomfjorden (3). Glaciers and Icecaps: Von Postbreen (1), Potpeschniggbreen (1), Negribreen (1), Wandbreen (1), Hayesbreen (1), Petermannbreen (1), Johansenbreen (1), Bråsvellbreen (3), Vegafonna, Sørfonna (3), Edmondbreen, Langhansbreen (1), Glitnefonna (3). Moun-tains: Friederichsenfjella (1), Vivienberget (1), Rejmyrefjellet (1), Pryzbyl-lokfjellet (1), Strökärrfjellet (1), Köpingfjellet (1), Seelheimfjellet (1), Gradberget (1), Maunoirberget (1), Hallberget (1), Malte Brunberget (1), Perthesfjella (1), Edlundfjellet (3), Sergievskifjellet, Svanbergfjellet (1), Aagaardfjellet (1), Svartknausane, Idunfjellet (2), Svartberget (3), Torell-nesfjellet, Bosleytoppane, Sandfordfjella, Rundhaugen, Angelineberget (3), Hahnfjella (1). Coastal features: Wahlenbergfjorden (2), Bosleybukta (2), Oxfordhalvøya (2), Claredonnæringane (2), Isispynten (2), Selanderneset (2), Ismåsestranda (2), Ulvebukta (3), Torellneset (2), Zeipelodden (2), Vibebukta (3), Augustabukta (3), Scaniahalvøya (3), Wichebukta (3). Islands: Wahlbergøya (3), Waigattøyane (3), Nystromøya (3), Wilhelmøya with its point Tumlingodden (3 and 2), Bastianøya (3), Rønnebeckøyane (3). Valleys and other land feature: "Bluff Cairn" (4), "Never-Never Cairn" (4),

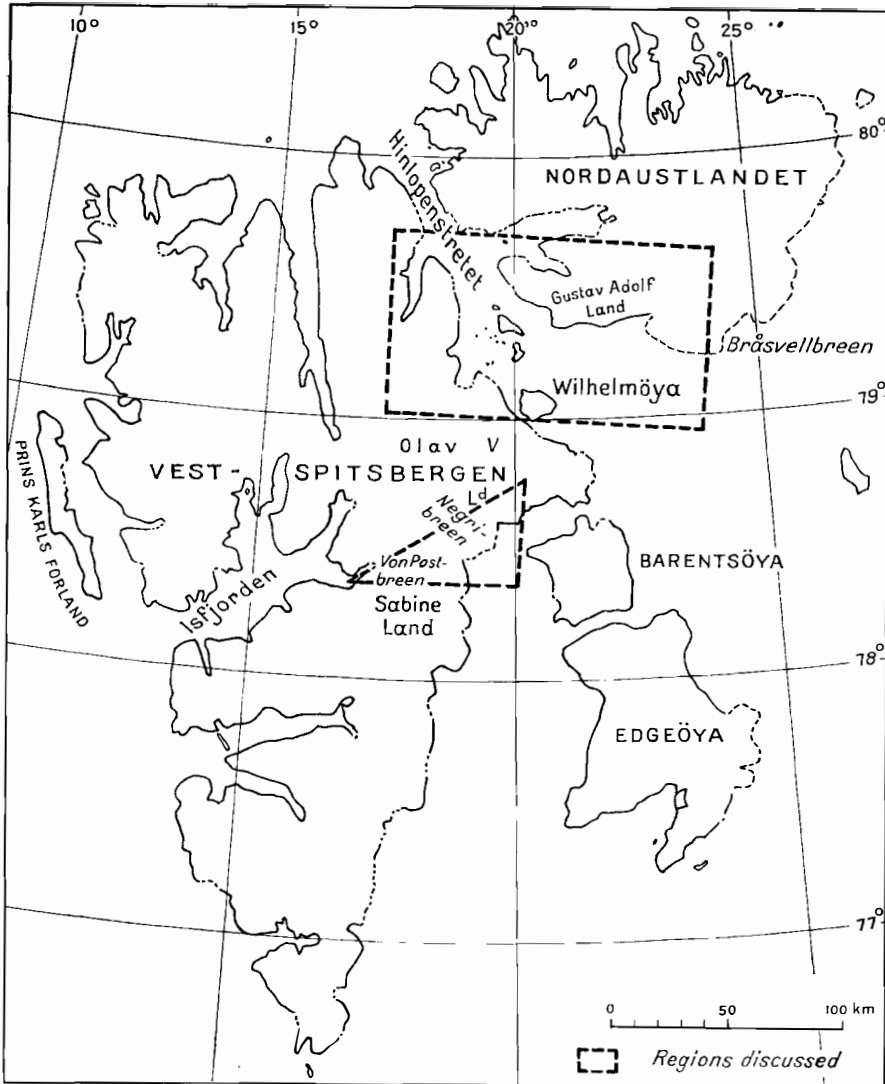


Fig. 1. Location map of Spitsbergen.

“Rough Rock Cairn” (4), “Rough Rock Valley” (4), Vibedalen, Palanderdalen (3).

One of the intrinsic difficulties of preparing work on Spitsbergen is that the spelling of place-names has changed frequently not only on maps and in literature from differing countries but also from any one country. Furthermore names have changed fundamentally with time or the features they are meant to indicate found to be non-existent. All the names used in this text are to be found on the source maps and sketches indicated above and the practice adopted in the text is to use the official Norwegian names, if other is not indicated.

Acknowledgements.

Throughout the preparation of this work I have been constantly guided and encouraged by Dr. K. S. Sandford and to him I am grateful for the many hours he has given up to help me. To Mr. J. M. Edmonds I would like to express my sincere thanks for his frequent help, especially in the identification of specimens. I am indebted to Dr. L. F. Spath for identifying the ammonites from Sabine Land and to Dr. L. R. Cox for the identification of the lamellibranchs.

The expeditions received a great deal of help from many Societies, organisations and firms; the Royal Society and the Royal Geographical Society provided financial support, and the Royal Navy transported the 1951 expedition to Spitsbergen and back; this expedition was also assisted by a detachment from the Royal Marines. Both expeditions were sponsored by the Oxford University Exploration Club and to the Officers and Members and especially Mr. John Hartog, Mr. Ian Davidson, Mr. Miles Rucklidge and Mr. Lynne Plummer and the other members of the two expeditions I would like to offer my thanks. Dr. Sandford made available specimens from the region of Idunfjellet, Mr. John Hollin provided me with specimens, descriptions, photographs and sketches of Svartberget; the sketch maps of Southern Nordaustlandet are based upon the 1949 and 1951 surveys of Capt. W. Scott-Moncrieff; Miss Elizabeth Shaw has kindly checked the manuscript. To the authorities of Norsk Polarinstitut and in Longyearbyen, and especially to Governor Balstad thanks are expressed for their generous and never-failing assistance.

A. Hecla Hoek Rocks in Northern Sabine Land, Vestspitsbergen.

From the head of Tempelfjorden in northern Sabine Land the writer, in 1953, sledged up the Von Postbreen, made possibly the first journey up the Potpeschniggbreen, crossed a high ice col and continued down a hitherto untraversed and unnamed glacier, called Edmondbreen by the expedition, to the south-east of the Friederichsenfjella to the Negribreen. At the base of Vivienberget, point 880 metres on Filchner's map of 1910, Hecla Hoek¹ rocks were found. (Fig. 2), (Map I).

At the north-eastern end of Vivienberget faulted cream and pink quartzites and dark limestones dip to the north-west at 70 degrees; a sill was included in the section but it was impossible to collect specimens or to examine it. Variegated green, red, yellow and purple shaly-slates cropped out

¹ For detailed discussion of the Hecla Hoek beds reference is made to Sandford 1926, Odell 1927, Kulling 1934, Fleming and Edmonds 1941, Sandford 1950, 1954 and 1955 and Harland and Wilson 1956.

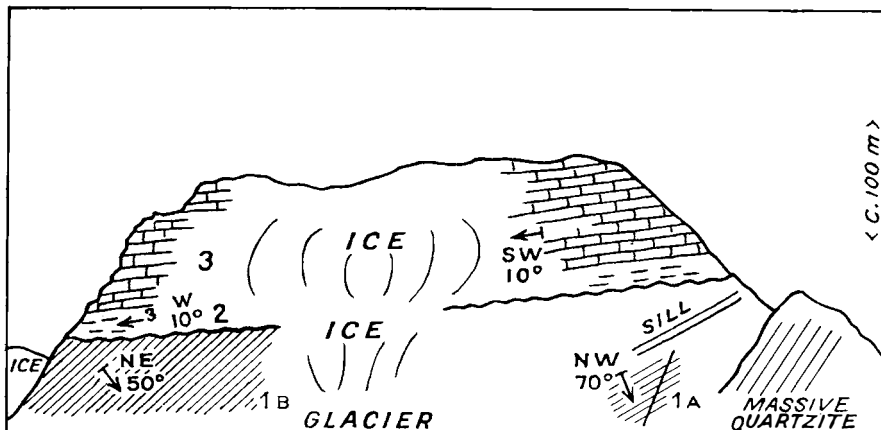


Fig. 2. Diagram of Vivienberget. 1 - Hecla Hoek. 1 A, quartzites and limestones; 1 B, shales and slates. 2 - Permo-Carboniferous sandstones and conglomerates. 3 - Permo-Carboniferous limestones and conglomerates.

at the south-western end of the mountain, dipping at about 50 degrees to the north-east; they are thinly bedded, laminated and frequently contorted. The junction between the two series was obscured by a small glacier and they may belong to Odell's groups (4) and (5) of his Upper Series of the Hecla Hoek Rocks, (Odell, 1927, pp. 150-152). Using Kulling's classification (Kulling, 1934) and following Fleming and Edmonds (1941, pp. 409 and 416) the beds may be correlated with the Lower Murchison Bay Formation. The Friederichsenfjella continue into Olav V Land and the mountains lying to the north-east of Negribreen are thought to consist of Hecla Hoek quartzites and of Permo-Carboniferous limestones and cherts.

B. I. Permo-Carboniferous Rocks in Northern Sabine Land, Vestspitsbergen.

In 1953 three sections were measured in the Rejmyrefjellet and the Pryzbyllockfjellet on the south side of Von Postbreen, in the north of Northern Sabine Land. (Map I.) The mountains were found to be entirely of Permo-Carboniferous rocks, belonging to the Cyathophyllum Limestones and the overlying Brachiopod Cherts, as defined by Gee, Harland and McWhae (1952, p. 342).

At the eastern end of the Rejmyrefjellet the following much simplified section was measured; the general dip is about 5 degrees to the south-east.

160 metres	Lower Permian	Brachiopod Cherts
	Predominantly medium-bedded, dark blue, grey and cream limestones, and cream, mottled brown and blue cherts. The beds form the summits of the Rejmyrefjellet. The Permo-Carboniferous Spirifer Limestones were not found but are believed to lie at the base of the Brachiopod Cherts.	

- 180 metres Upper Carboniferous Upper Gypsiferous Series of the Cyathophyllum Limestones.
- The upper part is mainly white and grey gypseous limestones, interbedded with platy, soft, grey unfossiliferous limestones; this upper ten metres is underlain by grey and fawn, massive unfossiliferous limestones. Further evaporites and limestones underlie these beds.
- 140 metres Upper Carboniferous 'Wordiekammen Limestones'¹ of the Cyathophyllum Limestones.
- Predominantly hard, light and dark grey limestones; medium to thick bedded and occasionally massive. They are fossiliferous with many brachiopods and corals profusely distributed, specially in the dark and black limestones lower in the succession. They were termed 'Waterfall Limestones' in the field on account of their relative resistance to stream erosion.

Further inland along the southern edge of the Von Postbreen the lower beds become successively overwhelmed by ice, and a greater thickness of Brachiopod Cherts is exposed. The Wordiekammen Limestones are not found on the Pryzbyllockfjellet, and the Upper Gypsiferous Series are seen to pass beneath the ice on the north side of that mountain. The following much simplified section was taken up the western ridge of Pryzbyllockfjellet, to the east of the Wandbreen. The summit of Pryzbyllockfjellet is given as 680 metres on Filchner's map. The thicknesses were taken by aneroid and are necessarily approximate; the topographic height of the section is about 400 metres. Certain slight flexures may complicate the section. The dip, again, is generally about 5° to the south-east.

- 270 metres Lower Permian Brachiopod Cherts.
- There are three main rock groups: 1. White, brown, and grey cherts, the white bands often highly fossiliferous; the beds are usually thin and much shattered; some cherts may be dark blue, forming nodular bands often interbedded with dark, platy and shaly limestones. 2. Medium to thin-bedded, fragmentary, fossiliferous limestones. Both types may form prominent cliffs. 3. Most common in the middle of the group, highly fossiliferous sandy-limestones.
- 30 metres Permo-Carboniferous Lower Brachiopod Cherts, the Spirifer Limestones.
- Medium to thick-bedded limestones, forming prominent vertical cliffs which are the main buttresses of this section of Pryzbyllockfjellet. The darker, blue limestones are the harder bands, the cream rocks being frequently rubbly and soft.

¹ A name proposed by Gee, Harland and McWhae, 1952, p. 342.

100 metres	Upper Carboniferous	Upper Gypsiferous Series of the Cyathophyllum Limestones.
------------	---------------------	---

The exposed beds begin with a light-grey, medium to thick-bedded fossiliferous limestone interbedded with coarse, rough, 'rag' limestones, but 20 metres above the ice the grey limestones are parted by thin, shaly bands with gypsum and concretions, and at 17 metres above the ice hard blue limestone is interbedded with argillaceous bands. Above 18 metres the limestones become generally coarser and rougher, the sandy bands more frequent, and shaly limestones, coarse sandstone and arenaceous bands with quartz pebbles appear. At about 85 metres above the ice are massive arenaceous bands and limestones forming impressive pinnacles. In the top 8 metres dark, carbonaceous limestones with thin, shaly coal bands are common.

At the north-east extremity of Pryzbyllockfjellet the higher beds of the Upper Gypsiferous Series are overwhelmed by ice and the Brachiopod Cherts merge into talus or ice; eventually all the rock is hidden by the ice carapace. The rock types discovered on the northern side of the mountain are found again on the eastern side dipping gently to the east-south-east.

The sledge journey to and along the Potpeschniggbrean revealed the Brachiopod Cherts to crop out in the mountains on the south-eastern side. Köpingfjellet was ascended by its north-east ridge and the commonest rock types were fossiliferous blue and white limestones, 'rag' limestones, and white and dark cherts, dipping to the south-east at about three degrees.

The line of the glacier approximately follows the strike and Brachiopod Cherts, mainly stained cherts dipping gently to the south-east, are found on Maunoirberget and point 795 on Filchner's map of 1910 at the head of the glacier. The same beds appear to make the peaks on the western side of Hayesbrean at least as far as Hallberget, where the beds were observed to steepen sharply in dip, to more than 45° to the south-east.

The sledge journey was continued across the ice-field at the head of Petermannbrean and down the glacier to the south-east of the Friederichsenfjella. Malte Brunfjellet was observed to be of medium-bedded Carboniferous limestones similar to those overlying the Hecla Hoek of Vivienberget, but it could not be reached due to the intense crevassing of the glacier.

The junction between the Hecla Hoek of Vivienberget and the overlying medium-bedded, fossiliferous sedimentaries appears to be unfaulted. (Fig. 2) The beds immediately overlying the Hecla Hoek are about 10 metres of cream, red, and variegated sandstones, siliceous beds with conglomerates of small pebbles, and breccia mainly of small quartzite fragments. The rock is medium-bedded and dips to the south-west at a maximum angle of ten degrees.

Above the red sandstones are at least 80 metres of medium-bedded grey, fossiliferous limestones, making castellated cliffs where they overlook the

glacier and probably belonging to the Brachiopod Cherts. The easternmost peaks of the line of mountains continuing the Friederichsenfjella towards Northern Sabine Land appear to be of limestones of Upper Carboniferous age.

Neither Permo-Carboniferous nor Hecla Hoek rocks are found in the heavily ice-covered hills facing Vivienberget on the south side of Edmondsbreen. At the north-western extremity of the Perthesfjella (called Sill Berge on Holland's map – K. S. S.) Triassic rocks are overlain by dolerite sills. Further to the north-east, in the extensive range of ice-encumbered hills called Sandfordfjella, from the point where Edmondsbreen debouches into Negribreen, Permo-Carboniferous rocks appear, capped by dolerite sills. They form the hills overlooking the south-western side of Negribreen as far east as the junction of Petermannbreen with Negribreen. The scarp of the dolerite-capped Triassic rocks is marked by the Perthesfjella to the west and south of Johansenbreen. There is, then, a marked difference from the structure shown on Orvin's map (A. K. Orvin, 1940) where Trias is shown to make the hills on the western side of Negribreen and the floor beneath the glacier. Trias capped with dolerite is known on the north-western side of Negribreen at Edlundfjellet and Sergievskifjellet, and Odell (1927) shows Carboniferous to lie between these peaks and the Hecla Hoek of Svanbergfjellet. It appears that the Carboniferous continues from Sandfordfjella into the basin of Negribreen, forms the hills on the south-western side of the glacier and underlies the Trias further to the west in the Perthesfjella (the junction may be seen in Bosleytoppane at the eastern end of the mountains), Wichmannfjellet, Aagaardfjellet, and reappears to the west of Hayesbreen.

The Permo-Carboniferous rocks capped by dolerite were observed at several points in the hills of Sandfordfjella, as far as the south-western side of Negribreen, during a sledge journey. At the south-eastern corner of the junction of Edmondsbreen with Negribreen some 50 metres of cherts and medium-bedded, grey limestones are overlain by about 17 metres of dolerites. The beds dip gently to the west-south-west, but, near to Edmondsbreen they are faulted and sharply folded down to the north-west to dip at a maximum angle of 45° . It is interesting to observe that the dolerite likewise dips down to the north-west and it is possible that the movement post-dates the emplacement of the dolerite, which is presumably Cretaceous in age (Tyrrell and Sandford, 1933). If the movements were Tertiary they may have been connected with the tectonic activity which Sandford (1926) claims to have been primarily responsible for the formation of Hinlopenstretet. He also claims that the emplacement of the dolerite may have been connected with and influenced by the early stages of the movements during the Cretaceous. It is significant that in the area under discussion the dolerites are found on the margins of important depressions in some of which there is evidence of possible Mesozoic or Tertiary movement.

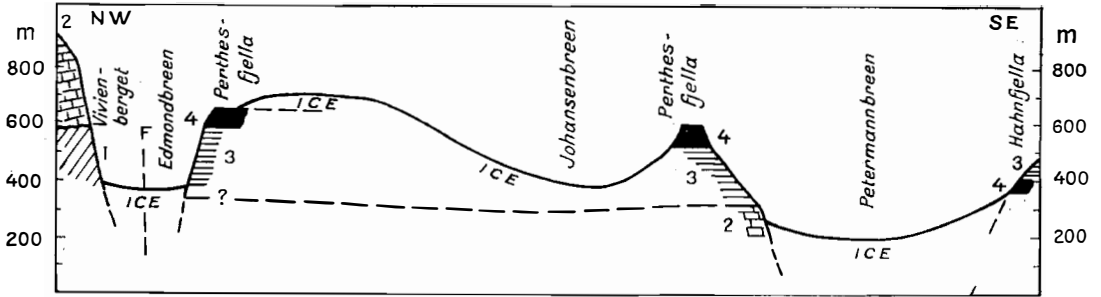


Fig. 3 a.

Fig. 3-4. Sketch section from Vivienberget to Hahnfjella, Sabine Land.
1 - Hecla Hoek; 2 - Permo-Carboniferous; 3 - Triassic; 4 - Dolerite; F - fault.

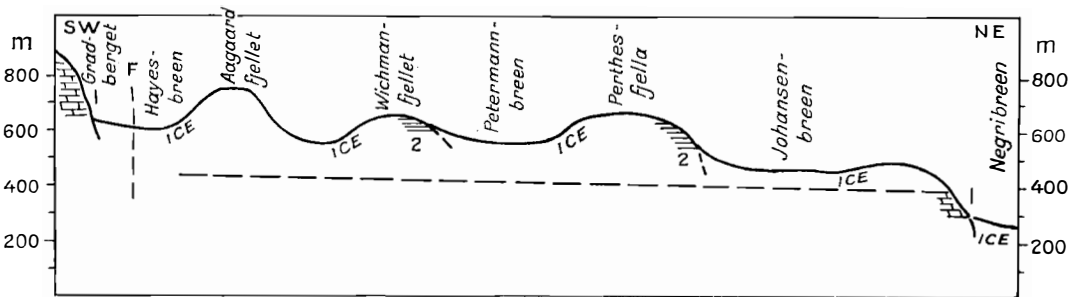


Fig. 3 b.

Sketch section from Gradberget to Negribreen, Sabine Land.
1 - Permo-Carboniferous; 2 - Triassic; F - fault.

One other sharp downfold to the north-west in Carboniferous rocks capped by dolerites was observed in the southern flank of a glacier tributary to Negribreen at approximately latitude $78^{\circ} 34'$ north longitude $18^{\circ} 40'$ east (this area has not been accurately mapped). The presence of an important fault along the line of Edmondbreen is strongly indicated; there is no indication of a faulted junction between the Mesozoic and Permo-Carboniferous strata in the region.

A section in one part of the south-western Negribreen cliffs, called Sandfordfjella (see Fig. 3, a and b, shows the following: the crag trends from north-west to south-east, the minimum height of the cliff here is 200 metres; the highland ice stands back from the cliff edge leaving an irregular, boulderstrewn surface. The dolerite cap forms a prominent scarp overlooking the Negribreen and there appear to be similar scarps on the north-eastern side of the glacier.

- 50 metres ?Cretaceous Dolerite
 dolerite sill with marked columnar jointing
- About 150 metres Permo-Carboniferous Brachiopod Cherts
- 10 metres thin-bedded platy, brittle, hard, blue limestones; the rock is baked indicating that the dolerite was emplaced directly into the limestones and they are unfossiliferous and weather brown.
- 17 metres medium-bedded, hard, blue limestones directly below the beds above and interbedded with grey unfossiliferous limestones.
- 23 metres of scree.
- 1 metre extremely fossiliferous, white, crystalline limestone, dipping at 5° to the south-east and overlying white chert with well-formed quartz crystals.
- 34 metres of scree.
- 10 metres platy, unfossiliferous, shattered, blue limestones dipping gently south-south-east.
- 7 metres thick-bedded, cherty blue limestones.
- 17 metres fossiliferous, thin-bedded, nodular grey limestones with with some argillaceous band.
- 7 metres fossiliferous hard, white limestones and white cherts.
- 7 metres scree.
- 13 metres white limestones.
- Scree chutes to the glacier.

B. II. Permo-Carboniferous Rocks in Vibe Land, Nordaustlandet.

Nordautlandet has been divided by Sandford (1926, 1950) into two provinces. The first is the Northern Province of ancient granites and gneiss, and of Hecla Hoek rocks (including Lower Palaeozoic sedimentary beds). 'Pink' granites or granodiorites are intruded into some of the sedimentaries and are known to be pre-Upper Carboniferous. The second, the Southern Province, consists of post-Lower Carboniferous beds, and it is in this area that the work to be described has been carried out. (Map II.)

In 1951 the writer, as a member of the Oxford University Expedition to Nordaustlandet (led by J. M. Hartog), measured the first complete Upper Carboniferous to Lower Permian succession to be found on the island. Evidence for the presence of Permo-Carboniferous on the northern and southern extremities of the Southern Province had previously been gained by various workers following De Geer (1923). In 1923 Elton made a collection from the land on the southern side of Vegafonna and Sørfonna, and Sandford (1926) has described the succession; the specimens were collected from the hills overlooking Vibebukta and Sandford assigned the beds to the *Spirifer* Limestones of the Permo-Carboniferous. The beds are calciferous sandstones with *Productus timanicus* Stuckenbergh, and higher up grey, cherty fossiliferous limestones with *Productus porrectus* Kut. In 1949

Thompson (1953, p. 295) found “. . . grey fossiliferous limestones and chert bands. . . exposed in a valley 15 feet deep to the east of the “Black Mountains” (Svartknausane). They lie flat and display north-south and east-west joint systems”. The present writer, having examined the specimens, believes that they also belong to the *Spirifer* Limestones.

On the northern side of Wahlenbergfjorden, at Idunfjellet, is the only post-Hecla Hoek outcrop found in the Northern Province until the recent discoveries of the Oxford Expedition of 1955. The exposure was described by Sandford (1926) who placed the beds found at the summit of the mountain in the Lower Permian *Productus* Beds. Rhynchonellids and other Brachiopods were found in the rocks. Sandford believed that certain ridges which project through the highland ice some miles north of Bodleybukta and Oxfordhalvøya may also be of *Productus* Beds. The inference is that Lower Permian and possibly Upper Carboniferous rocks lie beneath the highland ice in at least the western interior parts of Nordaustlandet. (Map III.)

In the same paper Sandford also describes the Permo-Carboniferous rocks which he examined in 1924 on the south side of Wahlenbergfjorden in the Ismåsestranda section of the Clarendonnæringane. These he also places in the *Productus* Beds and he shows (1926, 1954) that the Carboniferous escarpment continues to the east of the Clarendonnæringane although it is overwhelmed by ice, and he quotes the Permo-Carboniferous material found at Isispynten on the east coast. Sandford also postulates *Spirifer* Limestones beneath the *Productus* Beds of the Clarendonnæringane and the presence of Permo-Carboniferous material beneath the ice-caps of Vega-fonna and Sørfonna which lie on the upland south of Wahlenbergfjorden.

De Geer (1923) found the *Spirifer* Limestones at Selanderneset to a thickness of 140 feet, a considerable expansion from the maximum of 85 feet found in Vestspitsbergen (Gee, Harland and McWhae, 1952). The *Spirifer* Limestone is overlain by about 300 feet of the *Productus* Beds, and Sandford (1926) notes that “. . . there is not much difference of level or of thickness between Selanderneset and Ismåsestranda, and from the latter across the Southern Area to Ulvebukta the structure is probably simple”.

The *Productus* Beds, or Limestones as De Geer terms them, are seen at 200 metres at Selanderneset and they are observed to continue horizontal for some miles to the south along the eastern coast of Hinlopenstretet until they are cut off by an ice stream. Beyond the ice stream lies Svartberget, mid-way between Selanderneset and Torellneset, and here according to De Geer, is the one place where the Permian, as he knew it, is found in Nordaustlandet. Because the Permian here lies lower than the *Productus* Beds (which are now, on the palaeontological evidence of Stepanov (1937, p. 185) placed in the Permian) on the other side of the ice stream, De Geer assumes a fault “. . . because there is no marked flexure”. De Geer also notes Permian strata above *Productus* Beds on Wahlbergøya in Hinlopenstretet, but he includes no details.

Other relevant investigations carried out in the region were made by Kulling (1939) who found light-red to pink sandstones in an *in situ* boulder ground at Rundhaugen to the east of Zeipelodden to a height of 50 feet. It is possible that Kulling believes the sandstones to be Culm because he writes "...relying on Nordenskiöld's, 1893, information from Lomfjorden, Nat-horst, 1910, assumes the red and white sandstones east of the fjord to represent Culm..." when discussing the Permo-Carboniferous sections of Wahlenbergfjorden and Lomfjorden. Lomfjorden lies on the east coast of Vestspitsbergen, approximately continuing the line of Wahlenbergfjorden. A comparison will be made between these beds of Kulling and those found by the writer on the south coast of Nordaustlandet.

The following succession was established as a result of the field work in southern Nordaustlandet, the approximate thicknesses being derived from the section in Vibedalen:

	metres
4. The Upper Chert, Marble and Limestone Series, with <i>Stenopora ramosa</i>	30 (+)?
3. The Rough Limestones, with <i>S. ramosa</i> , <i>Spiriferella</i> , c. f. <i>lita</i> , etc.	40
2. The Cliff Limestones, with <i>Spiriferella</i> c. f. <i>polaris</i> , etc.	55
1. The Calciferous Sandstone Series, with <i>Productus</i> (<i>Horridonia</i>) <i>timanicus</i> , base not seen	45

A. The first section to be described, much simplified, was measured in Vibedalen, which lies between the western edge of the Bråsvellbreen and Sørfonna and on the eastern edge of Vibehøgden. (Map II.)

From a shallow, ice-filled scoop in the interior the valley becomes a deep, north-west to south-east trending trench between land rising to some 250 metres, with highly active streams. It then debouches into Vibebukta where the coast meets the ice-cliffs of Bråsvellbreen. The description begins on one of the rolling hills characteristic of Vibehøgden and continues down the valley to the sea. The specimens have been examined by Dr. K. S. Sandford and the provisional fossil determinations have been made by Mr. J. M. Edmonds. The field names given to the beds will be used as also will the series names with which the beds have been correlated.

4. The Upper Chert, Marble and Limestone Series:

These are a series of medium and thin-bedded white, cream and iron-stained cherts, of hard white and fawn limestones, and of white and green often 'spotted' marbles. The rock is brittle and shatters to sharp angular fragments which cover much of the hill summits and slopes in the region. Exposures in the 'sea' of debris were difficult to find but frost-shattered outcrops with dips of about 5 degrees to the north-east were found to approx-

imately 200 metres above sea level. Many of the rocks are fossiliferous and *Stenopora ramosa* Geinitz has been identified. With the underlying 'Rough Limestones' the series is correlated with the Lower Permian Productus Beds.

3. The Rough Limestones:

Two main groups of exposures were found, with the tops of three-metre outcrops at 186 metres and 146 metres above sea level respectively. They are fawn and light coloured, coarse, rough and rubbly, thinly-bedded fossiliferous limestones. The rock is frequently laminated, the laminae being opened-up by frost so that the rock shatters easily; estimations of the dip varied from the horizontal to slightly to the east. The following specimens have been recognised:

Spirifer cf. *ravana* Diener 1897; *Spirifer* cf. *moosakhaliensis* Davidson 1862; *Athyris* (*cleiothyridina*) sp.; *Spiriferella* cf. *polaris* Wiman 1914; *Spiriferella* cf. *lita* Fredericks 1924; *Productus arcticus* Whitfield; *Productus* sp. indet; *Stenopora ramosa* Geinitz; *Clysiophyllum nordenskiöldi* Toula; *Pecten* sp. indet.

The Rough Limestones are correlated with part of the Lower Permian Productus Beds.

2. The Cliff Limestones:

Extensive debris slopes separate the Rough Limestones from the Cliff Limestones which were found as a three-metre cliff with the top at approximately 129 metres above sea level. The rocks appear to have been recently exposed by stream action, and the rapid undercutting causes large blocks to break away. The exposures are generally very disturbed, and the dips were difficult to estimate on this account, but they appeared to be easterly to as much as ten degrees. The rocks are an alternating series of grey, fawn, blue and white, medium and thin-bedded limestones. Individual beds frequently show complex intermingling of the differing colours; the variation in colour seems to be haphazard and may be a weathering phenomenon. The white limestones are very pure and the fawn limestones often seem to be associated with white cherts. The rocks are highly fossiliferous and the following specimens have been identified:

Spirifer ravana Diener 1897; *Athyris* (*cleiothyridina*) sp.; *Spiriferella* cf. *polaris* Wiman 1914; *Derbyia grandis* Waagen; *Streptorhynchus kempei* Anderson; *Productus* (*Waagenoconcha*) *payeri* Toula; *Productus* sp. indet; *Clysiophyllum nordenskiöldi* Toula; also *Bryozoa*,? *Phyllopora laubeii* Toula, and crinoid ossicles. Scree slopes again obscure the section until a fossiliferous, milk-white and cream limestone occurs between 117 metres and 109 metres above sea level. The rock is medium to thick bedded and dips to the east-north-east at about three degrees; the top 2.5 metres are a darker, crystalline limestone, and other dark bands occur at irregular intervals.

Spiriferella keilhavii Von Buch and *Productus* (*Waagenconcha*) cf. *payeri* Toula have been identified, and certain bands of the rock are crowded with crinoid ossicles and Bryozoans, e. g. *Phyllopora* cf. *laubei* Toula.

Between 107 metres and 100 metres above sea level is a dark blue, thick-bedded, fossiliferous limestone. The top five feet are a whiter limestone with partings of carbon; lower down in the exposure are thinner-bedded, alternating grey and blue limestones. Many Bryozoa are present, including *Fenestella* sp. *Pecten* sp., *Styolites*, and a cast of part of a nautiloid were also found and good specimens of *Productus* (*Waagenconcha*) cf. *payeri* Toula. Between 88 metres and 100 metres above sea level are a series of alternating white, brown, fawn and grey limestones; they are fossiliferous, medium-bedded, and dip to the north-east at about 3 degrees. The following fossils have been identified:

Productus (*Waagenconcha*) cf. *payeri* Toula; *Productus* sp.; *Spirifer* cf. *ravana* Diener; *Aviculopecten* (*Dellopecten*) sp. cf. *mutabilis* Licharew.

There is a gap of some 30 metres of scree and ice-covered slopes before the subjacent beds outcrop, and inspection at a distance of exposures difficult of access indicates that beds of the Cliff Limestones occupy the intervening country. The Cliff Limestones are correlated with the Permo-Carboniferous Spirifer Limestones.

1. The Calciferous Sandstone Series:

The beds occur from about 60 metres above sea level down to sea level, and the following prominent outcrops were found: Two metres of well-jointed, fossiliferous, coarse grained sandstone and sandy limestone, varying from white to dark grey in colour and showing excellent current bedding; the beds dip just north of east at about 9 degrees. *Productus* (*Horridonia*) *timanicus* Stuckenbergh is to be found in these beds and in others lower in the series.

The section was obscured for another 3 metres and then there occurs 1.5 metres of grey-brown, thin-bedded, rough, nodular and fragmentary fossiliferous sandy limestones, dipping approximately 9 degrees to the east. Thin beds of pink sandstone are found among the predominant rock types and towards the top and bottom of the outcrop are some thin-bedded, dark, gritty limestones. *Productus* sp. and *Spirifer* sp. occur in the sandy limestones.

There is yet another gap in the section where it was obscured by talus, but from about 43 to 49 metres above sea level there are a series of pink and white, medium-bedded, coarse sandstones and limy-sandstones, dipping at about 5 degrees to the south-east, with *Spirifer* sp. and Bryozoa.

Between about 27 metres and 33 metres above sea level are a series of pink and white, coarse and crystalline, thin-bedded soft limestones, and hard, dark, grey limy-sandstones. The exposures were difficult of access, being hidden among the ice with moulin and great mounds of glaciofluvial

debris and protected by fast-flowing streams. No outcrop was examined for some 10 metres when a series of gypseous sandstones, light coloured sandstones, and limy sandstones were found between about 12 and 16 metres above sea level. The gypsum occurs as crystals and as small ramifying veins in the limy sandstone which is soft and crumbles easily. Several of the sandstones were darkened with carbonaceous matter. There is a general, gentle dip to the south in this group of exposures.

The lowest beds in the section were limy sandstones and grey limestones at about 11 metres above sea level, dipping to the south-west at 3 degrees.

This series is correlated with the Upper Carboniferous Upper Gypsiferous Series of the Cyathophyllum Limestones.

B. The second section to be described was measured in a valley one mile to the west of Vibedalen, cut into the southerly-facing escarpment overlooking Vibebukta; it is referred to as the Leirdalen ('Base Camp Valley') Section. The section begins at about 232 metres above sea level, at the summit of this part of Vibehøgden and was measured down the valley, which is partly ice-filled and partly stream eroded, to sea level. The section is simplified and the field names of the Vibedalen section are used.

4., 3. The Upper Chert, Marble and Limestone Series:

"The Rough Rock".

There is no definite outcrop on the summit area, but the 'dimpled' nivation surface, typical of periglacial regions and with a karstic appearance, is strewn with angular fragments of white iron-stained and cream cherts and limestone and white and green marbles; higher than 190 metres above sea level there is a prolific growth of lichen which may indicate that the area has been ice-free for a lengthy period. There are several distinct 'levels' making up the plateau and it was undecided whether they were structural or erosional in origin.

At 168 metres above sea level occur the fossiliferous cherts and limestones found in the previous valley and correlated with the Lower Permian Productus Beds.

Stenopora ramosa Geinitz was found especially in silicified limestones; all the outcrops are badly frost shattered.

2. The Cliff Limestones:

Between 122 metres and 138 metres above sea level are fossiliferous limestones similar to those in Vibedalen and dipping slightly north of west at 5 degrees; the rocks are characterised by lateral colour variation and vertical colour alternation. The following specimens have been provisionally identified:

Spiriferella cf. *polaris* Wiman 1914; *Spirifer* cf. *moosakhaliensis* Davidson 1862; *Athyris* (*Cleiothyridina*) sp. cf. *kotlukowi* Stepanov; *Spirifer* cf. *ravana* Diener 1897; *Streptorhynchus* cp. cf. *kempei* Anderson; *Productus* sp.

Four metres of pinnacle-forming fossiliferous cherts and grey, fawn, and blue limestones occur below 107 metres with thinner bands of fine-grained arenaceous limestone and dipping to the south-west at four degrees. *Productus* sp. (?*Productus* (*Productus*) *arcticus* Whitfield) has been provisionally identified. Ice-fringe and moraine obscure the section down to about 61 metres where there is a prominent bench, partly covered with beach debris in which stone and soil polygons have developed.

1. The Calciferous Sandstone Series:

The bench has a vertical cliff in places 9 metres high and facing the sea; in the cliff and stream bed the following rock types were found:

61 metres to 28 metres, grey limy-sandstones, being coarser or finer, and more siliceous or more calcareous at differing horizons, and displaying fine current bedding and lensing. Two other benches occur at 46 metres and 30 metres with greater quantities of beach debris.

6 metres of pink and grey fossiliferous sandy-limestones continue the above beds. The rocks have a gentle dip to the south which becomes more obvious lower in the series. Occasional coarser bands occur, one notably at 27 metres, and shelley bands as at 23 metres where there is cut a bench with clints, grikes, pavements and small caves and *in situ* limestone monoliths rising from the pavements. *Productus* sp. cf. *timanicus* Stuckenberg is found at several horizons.

From 12 to 21 metres above sea level are hard, grey, pink and buff unfossiliferous limestones dipping to the south at 4 degrees, as do the immediately subjacent coarse fawn and pink fossiliferous sandstones with frequent development of calcite crystals; *Productus* sp. are found.

Medium-bedded limy-sandstones and limestones underlain by sandstones showing conchoidal weathering are found from 3 to 11 metres; they are generally brown, iron stained and unfossiliferous with a strong development of calcite crystals and dip southwards at 4 degrees.

The final 3 metres are beach deposits which, like those in the estuarine reaches of Vibedalen, are being eroded by the stream to leave beach terraces.

C. The third series of outcrops to be described were found in a valley, named "Rough Rock Valley" in the field, 8.5 miles to the west of Vibedalen at the western end of Vibehøgdene, and on Vibehøgdene itself. To facilitate description the trigonometrical stations established for the survey of the upland will be used as reference points.¹ (Map II.)

¹ The field names applied to cairns are retained because it is difficult to eradicate them completely: from east to west they are:

At about 550 feet (168 metres) above sea level in a typical small valley running transverse to the Upland edge and midway between "Bluff Cairn" and "Never-Never Cairn", a stream has cut a small gorge in cherts and marbles of the Upper Chert, Marble and Limestone Series of the Productus Beds. An approximate and somewhat unreliable estimation of the dip was that it was gently to the west. "Never-Never Cairn" (660 feet) is on the summit of one of the typical rounded, smooth-contoured hill characteristic of the Upland and made of jumbled blocks and fragments of the Upper Chert, Marble and Limestone Series. In several of the relatively large valleys with their small streams, and at about 600 feet (183 metres) above sea level, *in situ* green marbles and hard, iron-stained cherts were found.

"Rough Rock Cairn" (550 feet) is built on an outcrop of the Chert, Marble and Limestone Series; the rocks are white, grey, blue and iron-stained fossiliferous cherts and hard limestones, and they are typical of several exposures about the Cairn. The greatest topographic height of a discovered exposure lay to the north-east of the Cairn at about 700 feet (214 metres) and consisted of green marbles and the characteristic 'spotted' marbles. A few metres below the exposure at "Rough Rock Cairn" are softer, thinbedded limestones with a prolific development of large brachiopod spines. No reliable dips were obtained, but approximate estimates of strike varied from north-south to north-north-west – south-south-east. A journey across the Upland in a north-easterly direction crosses a series of great waves with the crests representing the strike of the rocks. The country to the north-east of the Cairns was of typical rounded, rolling hills strewn with debris of the Chert, Marble and Limestone Series, and revealing rare outcrops. *Stenopora ramosa* Geinitz and *Spiriferella* sp. cf. *Sp. lita* Fredericks have been identified; a large species of *Productus*, and gastropoda and crinoid ossicles are present.

Two other exposures were found in "Rough Rock Valley": at about 550 feet (137 metres) above sea level and exposed in a deep stream-cut gorge are fossiliferous grey and white limestones with *Spiriferella* cf. *polaris* Wiman and a natural cast of *Streptorhynchus kempei* Anderson. Blue, hard, medium-bedded fossiliferous limestones were found at 350 feet (107 metres) and, like those at 137 metres, dip gently to the west; *Spirifer* sp., a Bryozoan cf. *Phyllopora laubei* Toulou, and crinoid ossicles are present. The beds in these last two exposures are correlated with the Permo-Carboniferous Spirifer Limestones of Vibedalen and Leirdalen.

Cairn at 780 feet (= 238 metres) = "Bluff Cairn"

Cairn at 660 feet (= 201 metres) = "Never-Never Cairn"

Cairn at 550 feet (= 168 metres) = "Rough Rock Cairn".

In the field altitudes were computed in feet, and mapped as such.

In the text they have been converted to metres, but, where confusion might arise, both are given. K. S. S.

There are a few interesting comparisons between the Permo-Carboniferous rocks collected by Sandford in the Wahlenbergfjorden area and those collected by the writer from Vibehøgden.

Lithologically the rocks of the Lower Permian Productus Beds (otherwise known as the Brachiopod Cherts) of Southern Nordaustlandet and those examined by Sandford at the upper parts of his Ismåsestranda section have similarities. Brownish and cream cherts, weathering yellow, are common to both areas, as are pale yellow limestones. In the strata of Vibehøgden *Stenopora ramosa* Geinitz frequently occurs, and this same species is to be seen in the cherts collected by Sandford (see his specimens D. 112, 1926). Also *Spiriferella* cf. *lita* Fredericks is to be found in Sandford's specimens 'D' (1926), and in those collected from the top of Idunfjellet on the north side of Wahlenbergfjorden, and it has also been provisionally identified in the Upper Chert, Marble and Limestone Series of Vibehøgden. *Phyllopora laubei* Toulou is also suggested as common to both series, and *Fenestella* cf. *rectiformis* Schlotheim may also be present in Sandford's specimens 'F' (1926).

B. III. The Succession and Structure of the Permo-Carboniferous Rocks of Vibehøgden, Nordaustlandet.

The nomenclature of the Upper Palaeozoic Beds of Svalbard has undergone considerable change. Sandford (1926; 1950) dates the strata which he found on the south and north sides of Wahlenbergfjorden as Permo-Carboniferous; Frebold (1935) places the upper part of the Cyathophyllum Limestones, the Spirifer Limestones and the Productus Beds of Spitsbergen in the Lower Permian. In 1937 Stepanov stated that the palaeontological evidence "... leads to the conclusion that the age both of the Productus Beds and even of the Spirifer Limestone of Spitsbergen must be recognised as Permian".

Gee, Harland and McWhae (1952) state that "... the Cyathophyllum Limestones are referred to the Upper Carboniferous after Frebold (1937) and Orvin (1940). Following the same writers, we consider the cherty group, the "Brachiopod Cherts" in this paper (n. b. Gee, Harland and McWhae group the Productus Beds and the Spirifer Limestones into the Brachiopod Cherts, 1952, p. 345) to be Lower Permian (Artinskian) in age, except for the basal fossiliferous Limestone – the Spirifer Limestone – which Frebold (1937, pp. 87–88) tentatively considers to be uppermost Carboniferous".

When Frebold was placing the Spirifer Limestone in the uppermost Carboniferous in 1937, Stepanov was placing it in the Permian, and he also writes: "The presence of (palaeontological) elements of Upper Permian and

their similarity to the Word Formation (of Texas) do not allow these deposits to be considered as Artinskian but permit their parallelization with the higher horizons of Lower Permian. . .” There is, then, some confusion in the dating of the Upper Palaeozoic beds of Vestspitsbergen and Nordaustlandet which has yet to be resolved.

A consideration of the sections described above indicates that the rock series of Vibehøgdene readily fall into three main groups:

<i>Age</i>	<i>Group</i>	<i>Beds in southern Nordaustlandet</i>
Lower Permian	Productus Beds	Upper, Chert, Marble and Limestone Series; the Rough Limestones.
Permo-Carboniferous	Spirifer Limestones	The Cliff Limestones.
Upper Carboniferous	Upper Gypsiferous Series of the Cyathophyllum Limestones	The Calciferous Sandstone Series.

The succession changes from sandy limestones at the base of the section, the shallow-water sediments indicating deposition close to a land mass providing quantities of debris, to pure, soft limestones, showing a change in the conditions of deposition though carbonaceous matter, which occurs frequently in the subjacent beds, is still common. The abundant, shallow-water fauna, and the lithological character of the Cliff Limestones enable correlation to be made with the Spirifer Limestones of Vestspitsbergen and Nordaustlandet. The Calciferous Sandstone Series with evaporites are compared with the Upper Gypsiferous Series of Vestspitsbergen on lithological and stratigraphical grounds (see Gee, Harland and McWhae, 1952, p. 342). The conformable series is completed by the Rough Limestones and the Chert, Marble and Limestone Series which have palaeontological, lithological and stratigraphical similarities with the Productus Beds found by Sandford and others in the region of Wahlenbergfjorden and on the west coast of southern Nordaustlandet.

From a comparison of the sections in the region of Wahlenbergfjorden and the southern coast, it is reasonable to conclude that the Upper Carboniferous to Lower Permian succession in the ice-free areas of the Southern Province of Nordaustlandet is conformable throughout, and it is possible to make an estimate of the structure beneath the icecaps. Sandford's conclusions about the structure and succession beneath Vegafonna and Sørfonna are correct except that the Productus Beds have not been so eroded as to be unrepresented in southern Nordaustlandet, where they are now shown to occur to a considerable thickness at the top of the section (Fig. 4) (Map III).

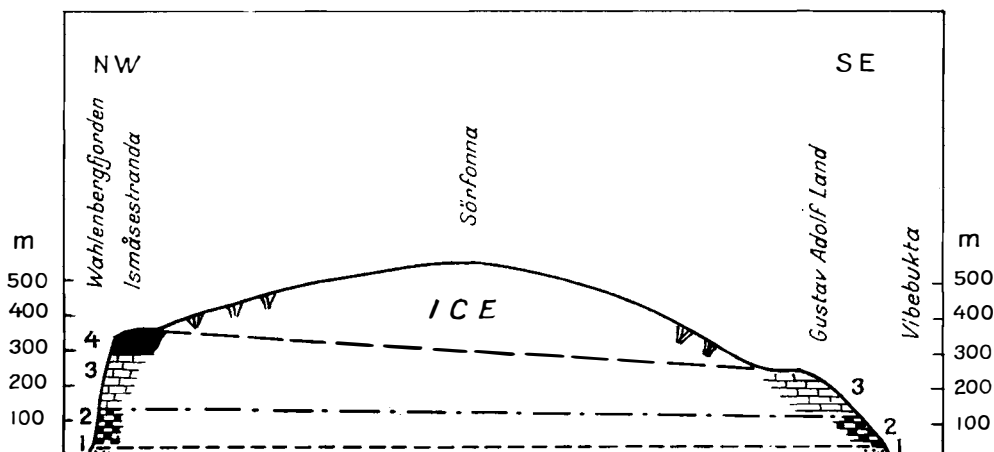


Fig. 4.

Sketch Section from Vibekbukta to Wahlenbergfjorden across Sörfonna.
Length of section 43 km. 1 - Upper Gypsiferous Series; 2 - *Spirifer* Limestones;
3 - Brachiopod Cherts; 4 - Dolerite.

Moreover, the *Spirifer* Limestones do not form the base of the section in Vibehøgdene, the Upper Gypsiferous Series underlies them, as is seen in Vibedalen and Leirdalen sections.

As has been mentioned above, Kulling (1934, pp. 212–213) found pink and red sandstones on the southern shore of Wahlenbergfjorden and, by comparing them with similar strata from Lomfjorden, inferred that they were Culm. It is worth mentioning here that the beds dated as Middle Carboniferous in the Lomfjorden area are the *Cyathophyllum* Limestones, which have had a varied history at the hands of different workers, oscillating between the Middle and Upper Carboniferous. Gee, Harland and McWhae (1952, p. 312) include the *Cyathophyllum* Limestones within the Upper Carboniferous.

The beds described by Kulling from Wahlenbergfjorden bear close comparison with the Calciferous Sandstone Series of Vibedalen, which have been placed in the Upper Gypsiferous Series of the *Cyathophyllum* Limestones. Both sets of exposures occur stratigraphically beneath the *Spirifer* Limestones, and they have lithological similarities, so we (i. e. M. F. H. and K. S. S.) conclude that Kulling's red and pink sandstones belong to the Upper Gypsiferous Series as described in Vestspitsbergen.

The Upper Gypsiferous Series is found in the south-eastern part of Vibehøgdene at the seaward end of two valleys, beneath the steep cliffs overlooking Vibekbukta. Here the raised beaches and platforms are not so wide as further west, and the cutting of sea-cliffs is in active progress, despite the seemingly limited time of the year when the shore is unprotected by sea-ice. The same Calciferous Sandstones make the nearby low coastal cliffs before disappearing beneath the sea to the west where the escarpment of Vibehøgdene becomes less definite and swings to the north-west, and where the raised beaches become much wider. The first solid rocks encountered in "Rough Rock Valley" are the Cliff Limestones, overlain by *Productus* Beds.

A consideration of the known geology, the relief, and a study of aerial photographs of Vibehøgden lead to the opinion that the upland consists of a gentle anticline, pitching near the estuary of Vibedalen in the south-east corner of the upland, and truncated by an erosion surface. Much of the surface of Vibehøgden slopes in a south-westerly direction and it is believed that it does so in harmony with the dip of the strata. The gentle dip and the relief account for the wide outcrop of the Upper Chert, Marble and Limestone Series, the shattered debris of which makes the surface of the rolling, dissected landscape between the narrow outcrop of the cliff-forming *Spirifer* Limestones and the ice edge. Though the measured dips are somewhat unreliable due to the intensely shattered nature of the limited exposures, they appear to have a definite western component on Vibehøgden and this is in accord with the stratigraphy.

To the west of Vibehøgden this supposed remnant of a Cenomanian peneplain (see Tyrrell and Sandford 1933, p. 289 and Ahlman, 1933) falls to a depression between the upland and the Svartknausane. The junction of the Permo-Carboniferous and Mesozoic beds has not been found in Nordaustlandet but, later in this paper, it is believed that it outcrops in the south-west of the island, to the north of the Torellnesfjella.

The depression there is occupied by an ice-lobe, by raised beaches and by a debris-strewn surface and it is unlikely that the junction will be satisfactorily investigated there, but the stratigraphy and succession support the claim to place it in the depression. The two outstanding problems connected with Permo-Carboniferous stratigraphy of Nordaustlandet are the junction with the overlying beds and the nature of the Upper Permian, if any is to be found in Nordaustlandet. The dating of the beds on Wahlbergøya and of the pre-Mesozoic beds to the north of the Torellnesfjellet may do much to solve these problems.

B. IV. Permo-Carboniferous Beds and Igneous Rocks in Southern Hinlopenstretet

When the Oxford University Expedition to Nordaustlandet, 1951, navigated the ice-blocked Hinlopenstretet the numerous detours and landings offered excellent opportunities for the investigation of the geology of the islands and shores of the strait. One of the most interesting islands visited was Wahlbergøya, one of the Waigattøyane, at roughly 79° 21' north and 20° east. Previously only de Geer had worked on the islands and he mentions (1923, p. 25) dolerites in the form of a sill, with *Productus* Beds overlain by Permian Shales. Sandford (1926) notes Wahlbergøya as one of the few exceptions to his usual entirely doleritic character of the islands of the strait, mentioning that it consists "... for the greater part of Permian and Carbo-Permian strata, rising to a height of 600 feet; instead of dolerite, which is present only in the form of a sill." (Map III.)

The present writer had only a few hours in the north-west of the island and found dolerite overlying baked limestones. The dolerite may be a sill,

though no upper junction was found, and with the limestone it dipped to the south-east at about 4 degrees. The dolerite has three prominent levels cut into it and, at one point on the west coast as seen from a boat, the lower part of the sill appeared to be complex, perhaps indicating more than one intrusion. The limestone surface on which the dolerite there rests appeared to be irregular.

The strata below the dolerite vary from a black, soft limestone to white, brittle marble which is medium to thin bedded and fossiliferous, with well developed crinoid stems and ossicles, and small brachiopods. The beds, especially where they are baked at the junction with the dolerite, are much shattered; the junction was obscured by scree at the places where the landings were made. The limestone has a prominent development of good calcite crystals and haematite staining is common near the contact. Locally the rock tends to be nodular and near the junction small structures are frequent, perhaps due to the thermal changes.

Being unable to pass down the west coast, the expedition sailed through the strait between Wahlbergøya and Nyströmøya, the latter island lies just to the north of Wahlbergøya. From the boat small anticlines were seen in the limestone, one limb of which, on Nyströmøya, showed an apparent dip to the north-west of about 50° and was truncated by a south-westerly dipping surface on which dolerite lies. At other points on the north coast of Wahlbergøya the limestone was absent, dolerite making the cliffs. The expedition then sailed down the east coast of Wahlbergøya through the strait between that island and Nordaustlandet. As observed from the boat limestones on the Nordaustlandet coast south of Angelinberget appeared to plunge beneath sea level, and at Svartberget and on the adjacent and opposite coast of Wahlbergøya folds were seen in limestones with dolerite truncating them and apparently dipping to the south-east.

Further south along the coast of Nordaustlandet, in Augustabukta, the character of the coastal cliffs changes, and they are no longer made of light-coloured limestones nor entirely of dolerite; they become blackish, rusty-brown and, in their upper parts, fawn in colour. The relief also changes, and the hills become rounded and 'softer' in form. Dolerite may cap some of the hills. At the time of observation it was thought that the change was due to the incoming of Mesozoic strata.

It has proved impossible to identify the fossils from Wahlbergøya and the most reasonable estimate of the age of the limestone is Upper Carboniferous or Lower Permian. It appears that after the deposition of the Carboniferous or Permian strata, folding took place, with possible uplift and erosion. The time of these happenings cannot be accurately estimated because any Triassic or Jurassic strata, if deposited, have been removed by erosion. If, as is generally assumed, (Sandford 1926, p. 651), (Tyrrell and Sandford 1933, p. 315) the age of the intrusions in the Hinlopen area is Cretaceous with an upper limit in the older Tertiary, then the foldings may

be pre-Cretaceous. They may represent the first manifestations of the Lower Cretaceous movements which Sandford (1926) claims to have originated the intrusions of the dolerites and to have been the inception of the formation of the fjords. It is reasonable to assume that Wahlbergøya was given its present form during the major faultings of the Tertiary and it may well be, as Sandford claims of the islands of the strait, a horst relic, in the graben of Hinlopenstretet.

Three aerial photographs of the south-western corner of Nordaustlandet, taken by Luncke in 1938 (Le. 90, Nos. 287, 290 and 292), have been examined in the light of field work carried out in Torellnesfjellet in the extreme south-west. De Geer (1923), Thompson (1953) and the writer have made investigations in this group of mountains and it is known that doleritic rocks and south-westerly dipping Triassic and possibly Jurassic strata emerge from beneath the southern edge of Vegafonna and are eventually covered by the strandflat beaches of the south coast. The Mesozoic rocks in Nordaustlandet are black and grey shales, and the rocks possibly subjacent to them are the Productus Beds of the Lower Permian. No other known rocks, excepting the Permian which De Geer mentions at Svartberget further north, are likely to underlie the Mesozoic strata. It is possible that the known Lower Permian may represent the whole of the Permian in Nordaustlandet, and if 'Upper' Permian was deposited it seems, from a comparison with adjacent areas of the south coast, to have been eroded.

The dolerites and Mesozoic rocks of Torellnesfjellet stand out well in one airphotograph, (and in the other two) there is a junction between an upper darkcoloured rock and a lower lighter-coloured rock showing prominently on a mountain side. It is seen at another point as a more indefinite line. The junction dips approximately to the north-west where it disappears beneath the west coast strandflat. There is an indication of an angular discordance at the junction. Little more can be gained without field investigation, but it seems that the upper dark-coloured rocks mentioned above at the junction represent Mesozoic rocks, probably Trias, and that they lie in the valley, Palanderdalen, between the two ice-caps of Vegafonna and Glitnefonna and make much of the plateau on which Vegafonna lies. The lower lightercoloured rock is presumed to be Permo-Carboniferous, probably Productus Beds, it is also seen, in the aerial photographs, to reach the surface, and probably makes at least part of the rock surface beneath the ice of Vegafonna. The lighter-coloured rocks, the presumed Permo-Carboniferous, are seen to extend towards Palanderdalen and Wahlenbergfjorden, where Permo-Carboniferous rocks have been examined; this lends support to the theory that the lighter-coloured rocks seen in the aerial photographs are Upper Carboniferous or Permian.

The observations made during the boat journeys through the strait thus suggest that the Permo-Carboniferous and Mesozoic junction in Nordaustlandet will eventually be found in the south-west corner of the island.

Postscript by M. F. H.: — Since these observations were recorded the writer has been fortunate enough to receive from Mr. J. T. Hollin eight specimens collected by him during his expedition to Nordaustlandet in 1955. He visited Svartberget and his observations are extremely interesting. The specimens undoubtedly belong to the Lower Permian Productus Beds, and are lithologically similar to the author's 'Chert, Marble and Limestone Series'. Furthermore they contain *Stenopora ramosa* Geinitz, (his specimen No. 99); also in Hollin's specimen No. 97 there is a concentration of crinoid ossicles comparable to that found by the author in lithologically similar rocks on Wahlbergøya. The correlation with the Lower Permian of the southern coast of Nordaustlandet and the Clarendonnæringane is quite satisfactory, and Hollin's field work confirms the author's observations.

It is interesting to repeat that it was at Svartberget that De Geer recorded, without additional details, the presence of Permian strata. What is perhaps even more interesting is the fact that Hollin records true dips of 37° and 45° with the dolerite becoming vertical near to the summit, which is made of dolerite. These observations made on the group agree with those made from the boat by the writer. Hollin also records that to the south of Svartberget all the outcrops to Torellnesfjellet appeared to be dolerite and he notes that for one or two miles immediately south of Svartberget there is a plateau of dolerite and raised beach, sloping gently to the sea. To the north of this locally contorted area (Svartberget) are the horizontal soft rocks (Productus Beds in fact) of the Scaniahalvøya; the dolerite fades out. This work provides additional support for the contention that post-Cretaceous movements took place in the region of Hinlopenstretet. It seems probable that there is no difference in the age of the rocks found at Svartberget and those to the north of the ice stream immediately north of Svartberget and it is improbable that this ice-stream marks the location of a fault (assumed by De Geer, 1923).

C. I. Mesozoic Rocks in Northern Sabine Land, Vestspitsbergen.

Note. The identification of ammonites collected from the sections described below were made by the late Dr. L. F. Spath and, with his notes upon them, were included in Holland's text. Subsequently the lamellibranchs have been studied by Dr. L. R. Cox, who has provided notes and comments upon them. Field collection-numbers on all Holland's specimens have enabled the lamellibranchs to be attributed to their appropriate beds. The whole of the text has been revised, but the following is essentially Holland's work. (Map I.)

K. S. S.

The three sections, A, B and C were examined in 1953 during the sledge journey to the Negribreen from Tempelfjorden.

A. North-western Perthesfjella

The section given below was measured in the cliffs at the north-western end of the Perthesfjella (called Silltoppane on Holland's map), facing Vivienberget. The altitudes mentioned are heights in metres of the various beds above the ice of Edmondbreen. The section is described from top to bottom.

- | | |
|-------------------------------------|---|
| 3 Dolerite | 10.5 metres thick, dipping south-south-east at about 10° in common with the underlying beds. The dolerite occurs at inconstant levels and interleaves the shales; it is much weathered. The edge of the ice stands back about 100 yards from the cliff edge, damming pools and diverting streams. Kames, eskers, moraines and erratic material (Permo-Carboniferous) with local dolerite and Triassic rocks are common on the weathered dip-slope of the sill. |
| 2 Baked Shales | Immediately beneath the sill are 4 metres of baked and altered black shales and thin-bedded fawn argillaceous limestones; the latter are often hard and iron-stained, with nodules containing lamellibranchs (<i>Posidonia?</i> sp.). There is much crystalline calcite. |
| 1 Alternating shales and limestones | Beneath the markedly baked beds are about 72 metres of alternating grey shales (baked higher up), and thin-bedded dark limestones and nodular beds.
Two fossiliferous nodular beds were examined at 61 metres and 25 metres. They have a similar ammonite fauna of <i>Nathorstites concentricus</i> (Öberg), <i>N. tenuis</i> and <i>N. gibbosus</i> Stolley. In the higher bed are <i>Halobia</i> n.sp., <i>Palaeoneilo</i> sp. and <i>Gervillia?</i> sp. In the lower bed <i>Pseudomonotis</i> sp. occurs. |

Spath refers the ammonites to the Ladinian stage, and they have been described from the Trias of other parts of Spitsbergen.

The exposures appear to mark the north-western extremity of the Trias of the Perthesfjella. The Permo-Carboniferous erratics indicate that the Triassic rocks do not entirely make up the country to the south-east of the exposure, and the outcrop of the Trias is quite narrow, the Permo-Carboniferous rocks appearing to its east and west.

At the south-eastern end of the Perthesfjella, lying between the Johansenbreen and the Petermannbreen and overlooking the Negribreen are the group of small mountains named Bosleytoppane by Holland. Here the Trias is seen to overly the Permo-Carboniferous and itself to be overlain by dolerites, but Holland was unable to visit the outcrops.

B. Hahnfjella

No Trias exposures were seen in the hills overlooking the Negribreen to the north-east of the Perthesfjella, but, to the north-west of Wichebukta, close to the snout of the Negribreen at the northern end of the Hahnfjella,

an extensive area of Lower Trias was examined. The following section was measured up the north-west face and ridge of the hill at the end of the chain. The general dip is to the south-east at about 8°; the heights are in metres above the ice of the Petermannbreen.

- 177 metres The summit: thin bedded blue shales with brittle fossiliferous limestone nodules containing *Arctoceras* sp. Spath notes that one specimen has the spiral lineation of *Arctoceras öbergi*, but it is strongly costate on the inner whorls like *Flemingites* (of the Eotrias). Lamellibranchs are: *Halobia* cf. *zitteli* Lindström and *Daonella* cf. *lindströmi* Mojsisovics. Also *Halobia* or *Daonella* sp., very large form.
- 168 metres Alternating blue shales and concretionary limestones which are found down to about 156 metres.
- 156 metres 7 metres of paper-thin blue shales with occasional iron-stained limestone nodules.
- 149 metres The blue shales pass to limestone-shales interbedded with bands of grey limestone and limestone concretions.
- 130 metres Thin, grey shales.
- 114 metres Four metres of fragmentary grey shales overlying a series of fragmentary grey and black shales interbedded with nodular limestones; at 76 metres they pass to thin-bedded fawn limestone-shales. In the upper part of the series *Arctoceras* sp., and Spath compares an ammonite impression to "*Lecanites*", ? as figured by Frebold, 1929, pl. I, fig. 1. Further down Spath identifies a new species of *Keyserlingites* (*subrobustus* group of Mojsisovics). No lamellibranchs are identified from these beds.
- 46 metres Thin-bedded, grey, baked shales: between this outcrop and the underlying dolerite are a series of fawn shales and laminated, platy, fawn, baked limestones.
- 31 metres Dolerite occurs down to the ice which was estimated to be at approximately 120 metres above sea-level.

Spath observes that the whole of the section is in the Lower Trias. Cox notes that *Halobia zitteli* Lindström has usually been attributed to the Carnian and *Daonella lindströmi* Mojsisovics to the Anisian, but there is no reason why closely comparable forms should not occur in the Lower Trias.

C. Wichmannfjellet

At an estimated local summit at approximately 473 metres (c. 1550 feet) and shown on Filchner's 1910 map at 515 metres, 23 metres of dolerite overly about 12 metres of thin-bedded flags and brittle, baked, blue shales. The beds are fossiliferous, but the collected ammonites are indeterminate; Spath notes that they show more resemblance to Lower Triassic ammonites

than to later groups, with the exception of possible impressions of *Gymnotoceras*, which is an Anisian form.

Cox has identified *Pseudomonotis* sp., *Posidonia mimer* Öberg, and *Pseudomonotis* (*Claria*) ? cf. *clarai* (Emmrich). The last is a characteristic species of the Werfenian stage of the Lower Trias, but Cox points out that the specimens are very ill-preserved and their identification is doubtful. *Posidonia mimer* Öberg is also a characteristic fossil of the Lower Trias in Spitsbergen (Frebold 1935, pp. 68, 74). The lamellibranchs come from platy grey flagstones, separated vertically from the overlying flags and brittle shales by 11 metres of dolerite.

The beds described above were investigated on the northern slopes of the mountain and the strata appeared to dip gently to the south-east. The relationship of the dolerite to the sedimentary rocks was also difficult to estimate in the time available. Despite the large quantities of scree, moraine and ice which obscured the rock it was concluded that the upper dolerite is a sill, and that the lower dolerite was probably a dyke. Scree, moraine and ice hide the lower part of the section, the ice of the Petermannbreen standing at approximately 320 metres above sea level at this point.

It seems that the Trias makes the country of the Perthesfjella, with the eastern boundary along the eastern edge of the mountains and the western boundary trending to the south-east to include the Wichmannfjellet and Aagaardfjellet in the Triassic area. The eastern boundary continues to Wichebukta, so that the Hahnfjella and much of Sabine Land is made of Triassic rocks. To the east and west the Trias passes to Permo-Carboniferous strata with dolerites, and to the north to Permo-Carboniferous (and Hecla Hoek) rocks. The details are shown on the accompanying diagrams (Figs. 3 a and b), and map.

C. II. Mesozoic Rocks in Nordaustlandet.

Thompson (1953) with the postscript by Sandford has given a detailed account of the Trias of Nordaustlandet and the dolerite, presumed to have been emplaced during the Cretaceous, has been discussed by Sandford (1926) and Tyrrell and Sandford (1933) and Thompson (1953). Apart from drawing attention to the discussion above (p. 29) on the aerial photographs of the south-west corner of the island, and to an unvisited exposure of presumed Trias dipping to the south-west lying to the south-east of the Svartknausane and identified from a group of photographs taken by the writer (the outcrop is shown on the accompanying map (Map III)), no further details will be mentioned here.

Sandford (1926) and Tyrrell and Sandford (1933) have concluded that the intrusion of the dolerites (and in southern Nordaustlandet the dolerites of Torellnesfjellet and the Svartknausane are thought to be sills and apophyses) was limited to the Cretaceous and, at latest, was completed in older

Tertiary times. It is worth mention that if the erosion surfaces are, as they are concluded to be, Cenomanian in age, and that the surfaces truncate folds in Permo-Carboniferous and Mesozoic strata, then the age of the intrusions in southern Nordaustlandet will be pre-Cenomanian and the foldings will be pre-Cenomanian also. Furthermore, dolerites were thought to lie across truncated folds in Permo-Carboniferous strata on Wahlbergøya, and as the dolerites are also known to have been disturbed by earth movements, for example on the southern margins of Negribreen, at least two periods of earth movement seem to be indicated, both pre-Cenomanian, one before and the other after or contemporaneous with the emplacement of the dolerite.

C. III. Mesozoic Rocks of Wilhelmøya.

Wilhelmøya (Wilhelm Island with its point Tumlingodden) lies at the southern end of Hinlopenstretet. It is situated off the Vestspitsbergen coast just north of the parallel of 79° north and slightly east of the meridian of 20° east. To the south-east of the island are entirely doleritic islands grouped in circular pattern, Bastianøyane and Rønnbeckøyane.

It is believed that only two parties of scientists have visited the islands. The first, surveyors and geologists, members of the Swedish-Russian Arc of Meridian Survey 1899–1902, who landed on the island in 1901. De Geer (1923) published the results of the work, and in 1935 and 1956 Frebold reconsidered De Geer's section in the light of other information from elsewhere in the archipelago. Fifty years after De Geer's visit, in the summer of 1951, a party from the Oxford University Expedition to Nordaustlandet was ashore on the island-mountain for about four hours and it proved possible to measure a section from Tumlingodden at 555 metres, down the southern slopes of the mountain to the raised beaches. Gaps in the section are mainly due to the lack of time to search among the mass of debris on the slopes for the scarce outcrops. Seen from a distance the dominating features on the steeply rising island are two bands of rock traversing the mountain and making marked breaks of slope.

The writer's specimens have been examined by Dr. K. S. Sandford and the fossils identified by Dr. L. R. Cox. The numbers refer to the numbered horizons of the writer's section which is discussed, and also compared with De Geer's and Frebold's work.

Tables.

In Holland's measured sections (1) and (2) are dolerite and black shales with gypsum. The dolerite is a faulted sill, dipping west-north-west and forming the summit and summit plateau; it is 37 metres thick. The sill is intruded into and envelops and bakes black shales in which there are

flattened impressions of ammonites, probably Perisphinctids of Upper Jurassic age; they are accompanied by impressions of *Buchia* (= *Aucella*) cf. *sublaevis* (Keyserling). De Geer found *Aucella* in black shales, and a highly decomposed amygdaloidal diabase; Frebold dates the shales as Lower Kimmeridgian.

(3) below the dolerite and shales the strata are not well exposed, but the isolated outcrops show a series of sandstones, flagstones and shales, 37 metres thick and dipping to the north-west at about 4°. Green, red and black clays are found on the surface along with a great deal of angular, shattered fragments of the harder beds; pebbles with circular cavities were

Correlation tables of Mesozoic succession at Tumlingodden, Wilhelmøya, based on Holland's notes: see text for detail and for identification of fossils.

K. S. S.

Height A. S. L. in metres	BED	Summit 555 metres on 1901 Trigonometrical Station
550	Lower Kimmeridge	Black shale with <i>Aucella</i>
	Upper Lias	Very decomposed amygdaloidal diabase 537-545m. Spherical concretions of light grey limestones with belemnites, saurian bones, ammonites etc., 521 m.
500		
450	Uppermost Trias	{ Sandstone with wind-eroded cave 463 m. Saurian bone (of local origin) 461 m.
	Upper Trias from here to the base of the section	{ Sandy shale with plant remains 439 m. Sandstone with limonite containing brachiopods 425 m.
400		
350		Shell-fragment limestone 360-373 m.
300	Diabase 298-308 m	
250		
200		0.20 m coal band 216 m. Nagelkalk (marne à cornets) 202 m <i>Aucella</i> 177 m.
150		
100		Ironstone with imprint of <i>Halobia</i> 137 m.
50		
0	Sea level	

Tumlingodden, Wilhelmøya, Section based on De Geer's published notes (1923), with Frebold's correlation (1935).

Height A. S. L. in metres	BED No.	Summit 555 metres on 1901 Trigonometrical Station (and 1951)
550	1 2	Baked, black shales (see De Geer in Frebold 1935, p. 78). Dolerite sill, shale on top and enveloping shales. Fossils
500	3 4	Series of sandstones and clays; NW dip 4°. Fossils Calcareous sandstone, ? NW dip 8°. 6 m.
450	5	The Flag Series, 65,5 m Upper red baked series
400	6	Lower grey sandstone series The Shattered Series, 23 m. Gentle WNW dip. All sandstones 6 i is a shelly band
350	7 8	Hard shelly limestone, chert at base. Fossils. 1.5 m. The Platy Series; mostly muds and flags and shales 44 m. 8 b traces of shells
300	9 10	a) Buff flags b) Hard, fawn limestone 30.5 m. c) Baked black and grey shales Dolerite sill with baked shales below it 23 m ? outcrops of dolerite also in 9.7? also slumped
250	11 12	Alternating series of sandstones, flagstones and shales with a thin, shelly, fawn limestone: nodular shelly band. 69 m. 11 b has bivalves. 11 c is shelly band Dark shales with mustard coloured sandstone below, 1.5 m 4.5 m with rounded nodules and iron concretions
150	13	Alternations of various sandstones with interbedded black and grey shales 122 m
100		
50		Scree Moraine Beaches to coastal plain and beach
0		Sea level

Tumlingodden, Wilhelmsøya. Holland's measured section 1951 (see text)
1-3 U. Permian, 7 Jurassic or Triassic, 11 Triassic? (Cor.).

also found on the surface and they may be moulds of belemnoids, although there is no trace of a former prismatic structure. Cox describes (3 d) as a hard, black rock with a flinty fracture containing *Buchia* (= *Aucella*) sp. indet; and the age as probably Upper Jurassic. At heights a little above these De Geer found spherical concretions of light-grey limestone with belemnites, saurian bones and ammonites, and Frebold gives an Upper Lias age to them.

Cox observes this as a noticeable discrepancy from his identification of *Buchia* at a similar height in the 1951 section.

The following ridge-forming rock types were seen; it proved impossible to estimate the thickness of the various beds due to the debris cover.

- (3a) very coarse, fawn sandstone of rounded quartz and other fragments.
- (3b) fine, variegated sandstone.
- (3c) medium-coarse, grey sandstone.
- (3d) hard black rock with flinty fracture containing *Buchia* sp.
- (3e) baked, variegated, calcareous sandstone.
- (3f) brown, platy sandstone.

(4) Below series (3) a bed of friable, whitish, calcareous sandstone is exposed; it is soft and crumbles to a harsh sand and yet is relatively hard enough to stand out as a pinnacle on the ridge; the bed is 6 metres thick with a doubtful dip to the north-west of 8°. Flakes of black shale were seen in the rock which also showed selective weathering and strongly developed current bedding. The rock is mentioned neither by De Geer nor Frebold.

(5) The Flag Series: 65.5 metres thick with a gentle dip to the north-west. The exposures are scattered and much broken and were found among a mass of broken, angular debris and areas of mud in which many stone rills are developed.

The following rock types were found:

The Upper Red Baked Group:

- (5a) platy-fine-grained, red, heavy sandstone.
- (5b) platy, brown sandstone.
- (5c) hard conglomerate in a hard, fawn sandstone.

The Lower Grey Sandstone Group:

- (5d) thin-bedded, grey and fawn, platy sandstone.
- (5e) 1.5 inches of thin-bedded, fine grey sandstone.
- (5f) thicker-bedded, medium coarse, grey sandstone with unidentifiable fossils.
- (5g) fine white calcareous sandstone.
- (5h) platy, medium-fine fawn sandstone.

At heights equivalent to the Upper Red Baked Group De Geer found a sandstone with a wind-eroded cave and just below this outcrop at a height of 461 metres he found a saurian bone of local origin; at heights similar to those of the Lower Grey Sandstone Group De Geer found a sandy shale with plant remains. Frebold gives an uppermost Triassic age for these beds discovered by De Geer. In the Lower Grey Sandstone Group specimens of fossil wood were found by the writer.

There is then a gap in the 1951 section, but De Geer lists a sandstone with limonite containing brachiopods. Frebold dates these beds and all those to the base of De Geer's section as Upper Triassic.

(6) The Shattered Series: Mainly sandstones, 23 metres thick, and dipping gently to the north-west; (6 i) is a shelly band of sandstone with unidentifiable lamellibranch remains.

The following rock types were found in a bed of a gully:

- (6a) mustard coloured, fine-grained sandstone.
- (6b) grey, medium-grained sandstone.
- (6c) grey, lightly iron-stained, calcareous sandstone.
- (6d) dark fawn, thin-bedded sandstone.
- (6e) grey, medium-grained sandstone.
- (6f) white, calcareous sandstone.
- (6g) hard, red-coloured sandstone.
- (6h) grey, medium-grained sandstone.
- (6i) dark fawn, shelly sandstone.

De Geer's section does not show any equivalent beds for the Shattered Series.

(7) A hard, shelly limestone 1.5 metres thick and coming in at the bottom of series (6) with a chert band at its base. Cox has the following comments to make of exposure (7): "... slabs of shale with specimens of a plicated oyster. If the rocks were known from other evidence to be of Upper Triassic age, the species would be identifiable as *Lopha montis-caprilis* (Klipstein), but this species has not been recorded hitherto from Spitsbergen or anywhere else in the Arctic Region. In the same matrix is a fragment of a valve of *Isognomon* (= *Perna*), showing the ligamental area. There is nothing definitely establishing the age of these specimens as Triassic, as *Lopha* could equally well be Jurassic or later."

(8) The Platy Series; mainly mudstones, flagstones and shales, 44 metres thick. (8 b) has broken shell fragments.

A doubtful gentle dip to the north-west was recorded.

- (8a) grey-brown, shaly flagstones; shales separate them from
- (8b) a hard limestone, encrusted with calcareous crystals.
- (8c) 3 metres of hard, red, platy rock with signs of sun cracks.
- (8d) greeny-grey mudstone; separated by shales from
- (8e) a grey sandstone; separated by black shales from
- (8f) a series of flagstones, with beds up to 2 inches thick.

(9) 30.5 metres of flagstones, limestones and shales. Beneath the flagstones, which make up most of this series and appear to be similar to those of (8 f), is a thin bed of hard, fawn limestone. Underlying the limestone are a few feet of baked, black and grey shales which lie directly above a sill.

(10) 23 metres of dolerite and subjacent baked, black shales; there are 7 metres of shale and dolerite scree below the solid rock. De Geer found a diabase sill at approximately the same height. On other parts of the hillside outcrops (probably apophyses) of the sill appear in series (9). Elsewhere the sill appears to divide, but this may be due to large-scale slumping.

The sill forms an abrupt change of slope, and some of the prominent dolerite cliffs are vertical.

(11) The Alternating Series: 69 metres of alternating sandstones, flagstones and dark shales with a thin-bedded, shelly, fawn limestone (11 b) and a nodular shelly band (11 c).

Cox describes (11 b) as a thin-bedded limestone full of lamellibranchs, some of which appear to belong to the genus *Pseudomonotis*; the species is indeterminate. The rock could be of Triassic age. Cox notes that (11 c) has ill-preserved lamellibranchs, one of which is rather like some species of the Triassic genus *Anodontophora* (for example *A. canalensis* (Catullo) and the form figured as "*Anoplophora*" sp. by Lagenham, 1915, pl 25, figs. 23 and 24). He adds that there is nothing definitely establishing a Triassic age.

(12) A group of dark shales, 1.5 metres thick, with 4.5 metres of mustard-coloured sandstone beneath them with rounded nodules and iron concretions. At approximately the same height above sea level, 216 metres, De Geer found a coal band, 0.20 metres thick, and at 202 metres he discovered nagelkalk (marne à cornets).

(13) 122 metres of sandstone alternating with black and grey shales and apparently continuing the 'Alternating Series'; the following sandstones separated by shales were noted in the field:

- (13a) buff, fissile, micaceous sandstone.
- (13b) grey, platy, calcareous sandstone.
- (13c) coarse, iron-stained, micaceous sandstone.
- (13d) medium-bedded, micaceous sandstone.
- (13e) coarse, medium-bedded, micaceous sandstone.
- (13f) thinner-bedded, micaceous flagstone.

These beds die out into the scree and moraines which fall to the raised beaches. There appear to be about 197 metres of the alternating sandstone and shale series, with eleven hard outcrops breaking the otherwise nearly continuous surface of debris. Softer flagstones and the shales separate the harder sandstones and they may be seen in the beds of gullies.

Physiographical History of Wilhelmøya.

Sandford, in his postscript to Thompson's paper on Southern Nord-austlandet (1953, p. 311) has compared the specimens collected by Thompson from the Svartknausane and the Torellnesfjellet in southern Nordaustlandet with those collected by the writer from Wilhelmøya. He comes to the conclusion that on lithological and stratigraphical grounds "... the black Triassic shales of Torellnesfjellet are Jurassic, with Upper Trias below them there and occurring in the eastern part of Svartknausane." He notes

that the occurrence of *Halobia* is at variance with the stratigraphical evidence, "... Jurassic rocks are therefore postulated but not proved in Southern Nordaustlandet".

In his consideration of De Geer's work on Wilhelmøya, Frebold (1935) gives an Upper Lias age to the light-grey limestone occurring beneath the diabase and *Aucella* shales which he dates as Lower Kimmeridgian; as already indicated they may correspond with the upper shales of Torellnesfjellet. At Tumlingodden there is a gap of some 15 metres between the two mentioned outcrops representing rocks laid down during the Middle Jurassic and lower part of the Upper Jurassic. In the 1951 section the gap is partially bridged, occupied as it is by a sill, and by the shales which Cox identified as Upper Jurassic from the occurrence of *Buchia* (= *Aucella*) cf. *sublaevis* Keyserling. He also identifies the same fossils in bed (3 d) which in the 1951 section apparently comes below the Upper Lias of De Geer. Cox observes that "... the most noticeable discrepancy is that Bed (3 d), assigned to the Lias in Frebold's section yielded a lamellibranch which seemed... to belong to the genus *Buchia* and to indicate an Upper Jurassic age".

Beneath the prominent Calcareous Sandstone Bed (4), found in 1951, Frebold considers all the rocks in De Geer's section to be Triassic. Cox finds nothing from the specimens collected in 1951 which would identify the beds below the Calcareous Sandstone as being Triassic; this, unfortunately, must apply also to the question of the age of the beds at Svartknausane and Torellnesfjellet.

It seems that only the occurrence of *Halobia* in De Geer's section at 137 metres identifies the beds below the Upper Lias as Triassic, and the Upper Lias determination is affected by the specimens (3 d) collected in 1951. Cox states that some of the beds and specimens may indicate a Triassic age, but there is nothing definitely establishing it; for example the *Lopha* of bed (7) may be Triassic, but it could equally well be Jurassic or later. There is, then, only a possibility that there may be a complete Upper Triassic to Upper Jurassic sequence on the island and that part of the section may be identified on Nordaustlandet, at Torellnesfjellet.

There is no indication of disturbance in the writer's section, but that earth movements may have occurred near to the area of deposition is supported by the finding of a conglomerate with Hecla Hoek sedimentary fragments in bed (5 c). The coarseness of some of the rocks, the presence of conglomerate and of fossil wood and carbonised remnants of plants, for example in Beds (4) and (5), suggest that deposition took place in shallow water close to land. The alternations of sandstones with shales found in the lower horizons may likewise indicate proximity to land, with possible frequent relative changes of sea level and depth.

The Mesozoic sedimentaries were then intruded by dolerites; sills are found baking the beds above and below them. Whether the strata were elevated to their present position before or after the intrusion, which is

presumed to have taken place in the Cretaceous, is not yet determined. The beds have been broken by a north to south fault along the eastern flanks of the island according to De Geer (1923), Sandford (1926) and Frebold (1935). In 1951 east to west faults were seen to displace the upper sill and it is possible that at least some of the faultings and movements of elevation were post-Cretaceous. The island may have been formed in the Tertiary contemporaneously with the powerful movements which disturbed Vestspitsbergen and possibly played a big part in the formation of the straits, fjords, sounds and large valleys in Vestspitsbergen and Nordaustlandet. The Tertiary earth movements were followed by the Quaternary glaciation, by the deposition of great quantities of unconsolidated debris testifying to extensive erosion, and by the recent cutting and deposition of raised beaches, indicating the latest relative movements.

References.

- AHLMANN, H. W:SON. 1933. Scientific results of the Swedish-Norwegian Arctic Expedition in the summer of 1931. Part V. Geomorphology. *Geogr. Annaler*. Stock. **15**.
- FLEMING, W. L. S. and J. M. EDMONDS. 1941. Hecla Hoek Rocks of New Friesland (Spitsbergen). *Geol. Mag.* **78**, 405–428.
- FREBOLD, H. 1935. *Geologie von Spitzbergen, der Bäreninsel, des König Karl- und Franz-Joseph-Landes*. Geologie der Erde. 1935. Berlin.
- 1937. Das Festnungsprofil auf Spitzbergen. *Skrifter om Svalbard og Ishavet*. **69**.
- 1951. Geologie des Barentsschelfes. *Abh. Deutsch. Akad. Wiss. Berlin, Kl. Math. Naturwiss.* 1950, **5**. (Abh. Geotekt. 4).
- GEE, E. R., W. B. HARLAND and J. R. H. MCWHAIE. 1952. Geology of Central Vestspitsbergen: Part I. Review of the Geology of Spitsbergen, with a special reference to Central Spitsbergen: Part II. Carboniferous to Lower Permian of Billefjorden. *Trans. Roy. Soc. Edin.* **62**, Pt. 2, (9), 1951–2, 299–356.
- DE GEER, G. J. 1923. Mission Scientifiques pour la Mesure D'un Arc de Meridien au Spitsberg. *Mission Suedoise*; **II**, pt. 9—Topographie et Géologie, 24 et seqq.
- HARLAND, W. B. and C. B. WILSON. 1956. The Hecla Hoek Succession in Ny Friesland, Spitsbergen. *Geol. Mag.*, **93**, (4), 256–286.
- KULLING, O. 1934. The Hecla Hoek Formation round Hinlopenstredet. *Geogr. Annaler*, 1934, 161–254.
- LANGENHAM, A. 1915. Versteinerungen der deutschen Trias, edit. 10 + 5 pp., 27 + 4 pl., and explanation. Hildebrandt in Walkershausen (published by the author).
- NATHORST, A. G. 1910. Beiträge zur Geologie der Bären Insel, Spitzbergens und des König-Karls-Landes. *Bull. Geol. Inst. Uppsala*, **10**, 261–247.
- NORDENSKIÖLD, A. E. 1863. Geografisk och Geognostisk Beskrifning over Nordosträ Delarne af Spetsbergen och Hinlopen Strait. *Kungliga Svenska Vet. Akad. Handl.* Stockholm, **IV**, (7), 1–25.
- ODELL, N. E. 1927. Preliminary Notes on the Geology of the Eastern Parts of Central Spitsbergen, with Special Reference to the Problem of the Hecla Hoek Formation. *Q. J. G. S.*, **83**, 147–162.
- ORVIN, A. K. 1940. Outline of the Geological History of Spitsbergen. *Skrifter on Svalbard og Ishavet*, **57**.
- SANDFORD, K. S. 1926. The Geology of North-East Land (Spitsbergen). *Q. J. G. S.* **82**, 615–665.
- 1950. Observations on the Geology of the Northern Part of North-East Land (Spitsbergen). *Q. J. G. S.* **105** (for 1949), 461–93.
- 1954. The Geology of Isis Point, North-East Land (Spitsbergen). *Q. J. G. S.* **110**, 11–20.
- 1955. (Abstract). The stratigraphy and structure of the Hecla Hoek Formation and its Relationship to a Subjacent Metamorphic Complex in North-East Land (Spitsbergen). *Proc. Geol. Soc. Lon.* **1531**, 14–15. (*Q. J. G. S.*, **112**, 1956, 539–62.)

- STEPANOV, D. L. 1937. Permskie Brachiopody Shpitsbergana (Permian Brachiopods of Spitsbergen). Trudy Arkt. Inst. Leningrad, **76**, 105–192.
- THOMPSON, H. R. 1953. Geology and Geomorphology in Southern Nordaustlandet, Spitsbergen. Proc. Geol. Assoc. **64**, Pt. 4, 293–312.
- TYRRELL, G. W. and K. S. SANDFORD. 1933. Geology and Petrology of the Dolerites of Spitsbergen. Proc. Roy. Soc. Edin., **53**, 284–321.

In the examination of the Permo-Carboniferous and Mesozoic material the following references were extremely useful (in addition to those mentioned above):

- CHAO, Y. T. 1929. Carboniferous and Permian Spiriferids of China. Palaeontologica Sinica. Series B. **11**, (1).
- FREBOLD, H. 1929. Die Schichtenfolge des Jura und der Unterkreide an der Ostküste Südweste-Spitzbergens. Abh. vom Naturwiss. Verein in Hamburg, **22**, **3-4**, (1), 253–292.
- 1929. Faunistische-stratigraphische Untersuchungen über die Trias Spitzbergens und der Edge Insel. Abh. vom Naturwiss. Verein in Hamburg. **22**, **3-4**, (1), 294–312.
- 1931. Das Marine Oberkarbon Ostgrönlands. Medd. om Grönland. **84**, (2).
- 1942. Über die Productiden des Brachiopodenkalkes und der Mallemukformation des nördlichen Ostgrönland und die Altersfrage einiger jungpaläozoischer Bildungen der Arktis. Skrifter om Svalbard og Ishavet, **84**.
- GRIPP, K. 1929. Glaciologische und Geologische Ergebnisse der Hamburgischen Spitzbergen-Expedition, 1927. Abh. Naturwiss. Hamburg. **22**, **3-4**, (1), 146–249.
- HINDE, G. J. 1888. On the Chert and Siliceous Schists of the Permo-Carboniferous of Spitsbergen and on the Characters of the Sponges therefrom, which have been described by E. V. Dunikowsky. Geol. Mag., **5**, 241.
- REED, F. R. COOPER. 1925. Upper Carboniferous Fossils from Chitral and the Pamirs. Mem. Geol. Surv. India. Palaeontologica Indica. New Series, **16**, Memoir **4**.
- 1927. Palaeozoic and Mesozoic Fossils from Yun-Nan. Memoirs of the Geol. Surv. India. Palaeontologica Indica. New Series, **10**, Memoir **1**.
- SPATH, L. F. 1951. Catol. Fossil Cephalopoda, B. M., Pt. V, 1951, 141–145.
- SPIZHARSKY, T. N. 1937. The Geological Structure of Franz-Joseph Land. Trudy Arkt. Inst. Leningrad, **76**, 39–73.
- STENSIÖ, E. A. 1918. Zur Kenntnis des Devons und des Kulms an der Klaas Billenbay, Spitzbergen. Bull. Geol. Inst. Uppsala, **16**, 65–80.
- TOULA, F. 1873. Kohlenkalk-Fossilien von der Südspitze von Spitzbergen. S. B. Akad. Wiss. Wien. **63**, 267–291.
- 1875. Kohlenkalk- und Zechstein Fossilien aus dem Hornsund and der Südwestküste von Spitzbergen. S. B. Akad. Wiss. Wien. **70**, Abt. I, Jahrg. 1874, 133–156.
- 1875. Permo-Carbon-Fossilien von der Westküste von Spitzbergen. (Bellsund, Cap Staratschin, Nordfjord). Neues Jahrbuch für Min. Geol. Paläont. 1875, 225–264.
- 1875. Ein Kohlenkalk-Fauna von den Barents-Inseln. S. B. Akad. Wiss. Wien, **71**, 527–608.
- TSCHERNYSCHEW, T. 1902. Die Obercarbonischen Brachiopoden des Urals und des Timan. Memoir du Comité Géologique. **16**, (2).
- TYRRELL, G. W. 1923. Stratigraphical Observations in the Storfjord Region of Spitsbergen. (With an appendix by WEIR, J. on the Mesozoic Fossils Collected by Tyrrell). Trans. Roy. Soc. Edin., **17**, Pt. III, 675–697.

Postscript.

In the course of the publication Holland makes several references to an early Cretaceous age of the dolerites, which is based on work now some thirty years old (Tyrrell and Sandford, 1933, and for Nordaustlandet, Sandford, 1926 (where the range is extended to include older Tertiary)). The attribution may well be correct, but will be subjected to revision that may arise from Palaeomagnetic studies (e. g., Harland, *Polar Record* 9, 1959, pp. 557–561).

Holland also refers to the structural origin of Hinlopenstretet, Wahlenbergfjorden, and other features, based on Sandford, 1926. Here also later work, especially Ahlmann, 1933, emphasizes that the physiographical features are of extrinsic origin (including glaciation); in some instances they may have been influenced by structural control.



View northward of Upper Carboniferous and Lower Permian sediments on the west side of the Bråsvellbreen. Their structure is recognized as anticlinal, the crest on the east, near the ice, being cut by a deep valley. Generally, the exposed beds dip gently to the south-west, and the limestone cliffs on the coast descends in that sense. The uplands, regarded as a remnant of a Cenomanian peneplain, consist of limestones and cherts, sandstones at the bottom of the section outcrop near the base of the eastern cliffs. Photo: Norsk Polarinstitut. No. Le. 91, 1938.



Palanderdalen, with Vegafonna on the right and the margin of Glitnefonna on the left. Light-coloured Upper Carboniferous and Lower Permian rocks, on the left, are covered by dark Mesozoic, probably Triassic, beds. The line of junction, which may be discordant, disappears beneath the superficial deposits (including raised beaches). Photo: Norsk Polarinstitut, No. Le. 91, 1938.

- Nr.
97. WÄNGSJÖ, GUSTAV: *The Downtonian and Devonian vertebrates of Spitsbergen. Part IX Morphologic and Systematic Studies of the Spitsbergen Cephalaspids. A. Text, and B. Plates.* 1952. Kr. 75,00.
 98. FEYLING-HANSSSEN, ROLF W.: *The Barnacle Balanus Balanoides (Linné, 1766) in Spitsbergen.* 1953. Kr. 8,00.
 99. RODAHL, KÅRE: *Eskimo Metabolism.* 1954. Kr. 10,00.
 100. PADGET, PETER: *Notes on some Corals from Late Paleozoic Rocks of Inner Isfjorden, Spitsbergen.* 1954. Kr. 1,00.
 101. MATHISEN, TRYGVE: *Svalbard in International Politics 1871—1925.* 1954. Kr. 18,00.
 102. RODAHL, KÅRE: *Studies on the Blood and Blood Pressure in the Eskimo, and the Significance of Ketosis under Arctic Conditions.* 1954. Kr. 10,00.
 103. LØVENSKIOLD, H. L.: *Studies on the Avifauna of Spitsbergen.* 1954. Kr. 16,00.
 104. HORNBÆK, HELGE: *Tidal Observations in the Arctic 1946—52.* 1954. Kr. 2,50.
 105. ABS, OTTO und HANS WALTER SCHMIDT: *Die arktische Trichinose und ihr Verbreitungsweg.* 1954. Kr. 4,00.
 106. MAJOR, HARALD and THORE S. WINSNES: *Cambrian and Ordovician Fossils from Sørkapp Land, Spitsbergen.* 1955. Kr. 4,00.
 107. FEYLING-HANSSSEN, ROLF W.: *Stratigraphy of the Marine Late-Pleistocene of Billefjorden, Vestspitsbergen.* 1955. Kr. 22,00.
 108. FEYLING-HANSSSEN, ROLF W.: *Late-Pleistocene Deposits at Kapp Wijk, Vestspitsbergen.* 1955. Kr. 3,00.
 109. DONNER, J. J. and R. G. WEST: *The Quarternary Geology of Brageneset, Nordaustlandet, Spitsbergen.* 1957. Kr. 5,00.
 110. LUNDQUIST, KAARE Z.: *Magnetic Observations in Svalbard 1596—1953.* 1957. Kr. 6,00.
 111. SVERDRUP, H. U.: *The Stress of the Wind on the Ice of the Polar Sea.* 1957. Kr. 2,00.
 112. ORVIN, ANDERS K.: *Supplement I to the Place-Names of Svalbard. Dealing with new Names 1935—55.* 1958. Kr. 13,00.
 113. SOOT-RYEN, TRON: *Pelecypods from East-Greenland.* 1958. Kr. 4,00.
 114. In preparation.
 115. GROOM, G. E. and M. M. SWEETING: *Valleys and Raised Beaches in Bünsow Land, Central Vestspitsbergen.* 1958. Kr. 3,00.
 116. SVENDSEN, PER: *The Algal Vegetation of Spitsbergen.* 1959. Kr. 7,00.
 117. HEINTZ, NATASCHA: *The Downtonian and Devonian Vertebrates of Spitsbergen. X. Two new Species of the Genus Pteraspis from the Wood Bay Series in Spitsbergen.* 1960. Kr. 3,00.
 118. RODAHL, KÅRE: *Nutritional Requirements under Arctic Conditions.* 1960. Kr. 8,00.
 119. RAPP, ANDERS: *Talus Slopes and Mountain Walls at Tempelfjorden, Spitsbergen.* 1960. Kr. 25,00.
 120. ORVIN, ANDERS K.: *The Place-Names of Jan Mayen.* 1960. Kr. 14,00.
 121. CARSTENS, HARALD: *Cristobalite-Trachytes of Jan Mayen.* 1961. Kr. 3,00.
 122. HOLLAND, MICHAEL FRANK WILLIAM: *The Geology of Certain Parts of Eastern Spitsbergen.* 1961. Kr. 12,00.

MAPS

General, geographical, topographical and technical maps:

DRONNING MAUD LAND				Kr.
Jutulgryta ..	H 5	1:250,000	1961	5,55
H. U. Sverdrupfjella	H 6	1:250,000	1961	5,55
Sør-Rondane		1:250,000	1957	5.55
GRØNLAND, Austgrønland				
Eirik Raudes Land				
Frå Sofiasund til Youngsund ..		1:200,000	1932	2.20
Claveringøya		1:100,000	1937
Geographical Society-øya		1:100,000	1937
Jordan Hill		1:100,000	1937
				From: Karte von Nordostgrönland. Publ. by NSIU 1937. Limited stock, not for sale.
JAN MAYEN				
Jan Mayen		1:100,000	1955	2.20
Sør-Jan.	Sheet 1	1: 50,000	1959	5.55
Nord-Jan	2	1: 50,000	1959	5.55
				Preliminary map.
SVALBARD				
Svalbard		1:2,000,000	1958	2.20
Prins Karls Forland	A 8	1:100,000	1959	5.55
Isfjorden	B 9	1:100,000	1955	5.55
Van Mijenfjorden	B 10	1:100,000	1948	5.55
Van Keulenfjorden	B 11	1:100,000	1952	5.55
Torellbreen	B 12	1:100,000	1953	5.55
Adventdalen	C 9	1:100,000	1950	5.55
Markhambreen	C 12	1:100,000	1957	5.55
Sørkapp	C 13	1:100,000	1947	5.55
Adventfjorden—Braganzavågen .		1:100,000	1941	2.20
Hopen		1:100,000	1949	2.20
(Claims to land in Svalbard)		1: 50,000	1927	2.20
Bjørnøya		1: 25,000	1925	5.55
				Preliminary map. each. 33 sheets.
Bjørnøya		1: 10,000	1925
				New ed. 1944 and 1955. Also as supplement to Skrifter Nr. 86. 6 sheets. Out of print.

The maps are distributed by Norges Geografiske Oppmåling, St. Olavs gt. 32, Oslo.

A wall map:

Norden og Norskehavet 1:2,500,000 1959 Revised edition.
Is to be obtained through H. Aschehoug & Co. (W. Nygaard), Oslo.

CHARTS

				Kr.
501	Bjørnøya	1: 40,000	1932	10.00
502	Bjørnøyfarvatnet	1:350,000	1937	10.00
503	Frå Bellsund til Forlandsrevet med Isfjorden	1:200,000	1932	10.00
504	Frå Sørkapp til Bellsund	1:200,000	1934	10.00
505	Norge—Svalbard, northern sheet	1:750,000	1933	10.00
506	» » southern »	1:750,000	1933	10.00
507	Nord svalbard	1:600,000	1934	10.00
508	Kongsfjorden og Krossfjorden	1:100,000	1934	10.00
509	Frå Storfjordrenna til Forlandsrevet med Isfjorden	1:350,000	1946	10.00
510	Frå Kapp Linné med Isfjorden til Sorgfjorden	1:350,000	1946	10.00
511	Østgrønland, fra Liverpool Kyst til Store Koldeweys Ø (rev. 1958)	1:600,000	1937	10.00
512	Jan Mayen	1:100,000	1955	10.00
513	Svalbard—Havner	various	1959	10.00
514	Barentshavet	1:2,000,000	1960	10.00

The charts are distributed by Norges Sjøkartverk, Stavanger.